"NO FISH, NO NIMAT":

ARCTIC SOCIAL-ECOLOGICAL SYSTEMS

IN THE CONTEXT OF GLOBAL CHANGE

Dissertation

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To my beloved brother...

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Nimat is a Tungusic traditional custom of sharing prey and thus establishes social relations with other people. Over the last decades, due to environmental and climatic changes numbers of caught fish are decreasing, therefore the tradition of *nimat* is vanishing.

Summary

The Arctic is undergoing rapid transformations as a result of global change. Global change drivers significantly affect Arctic biodiversity as well as ecosystem functioning: climate change results in shifts of natural habitats of many animals and plants; land use and technological adaptation cause migration route changes of numerous animals; the expansion of non-native species forces out native ones; and overexploitation brings about an extinction of many native species. Arctic indigenous and local communities are also dramatically affected by global change since they are highly dependent on biodiversity and ecosystem services for food, economy and socio-cultural well-being. Moreover, the livelihoods of indigenous and local communities are challenged by socio-political as well as economic stresses and shocks.

This thesis aims to assess the vulnerability and adaptive capacity of the Arctic social-ecological systems. In doing so, the thesis examines indigenous and local knowledge of global change drivers and their effects on the social-ecological systems. Social-ecological systems represent complex interactions of humans and nature. In the case of accelerated global change, the vulnerability of social-ecological systems may be increased and thus may compromise their sustainability. The thesis is based on two case study areas in the Arctic regions of the Republic of Sakha (Yakutia) in North-Eastern Siberia, Russia, where indigenous (Eveny, Evenki, Sakha) and non-indigenous (Russian, Ukrainians etc.) community members have been interviewed. It employs a mixed methods approach: 34 qualitative in-depth interviews, participant observation, two focus group discussions and 204 quantitative standardized questionnaires have been carried out in four Arctic settlements.

The study has shown that Yakutian communities face multiple global change related stresses. These stresses significantly affect livelihoods of the indigenous and local communities as well as their traditional practices (hunting, fishing, gathering and reindeer herding). As a result, food security of the indigenous and local communities is challenged. Indigenous and local communities have developed adaptive strategies to a changing climate and environment (changing fishing grounds in case of fish shortage, consumption habits change, just to name a few). However, their adaptive potential is constrained by socio-political and economic transformations (i.e. the collapse of the Soviet Union or new fishing laws). The interplay of aforementioned climatic stresses and socio-political shocks and trends increase the vulnerability of local and indigenous communities' livelihoods. Therefore, in order to maintain or increase the sustainability of Arctic social-ecological systems, it is necessary to take into account indigenous and local knowledge in developing and implementing conservation policies.

Zusammenfassung

Die Arktis ist aufgrund des globalen Wandels rasanten Veränderungen unterworfen. Verschiedene Treiber des globalen Wandels haben einen starken Einfluss auf die arktische Biodiversität und das Funktionieren der Ökosysteme: Der Klimawandel führt zu Verschiebungen natürlicher Habitate vieler Tier- und Pflanzenarten; Anpassungen in Landnutzung und Technologie verursachen Veränderungen der Migrationsrouten zahlreicher Tiere; die Ausdehnung von zugewanderten Arten vertreibt einheimische Arten; und Übernutzung hat die Ausrottung vieler einheimischen Arten zur Folge. Auch die indigenen und lokalen Bevölkerungsgruppen sind vom globalen Wandel dramatisch betroffen, da sie stark von Biodiversität und Ökosystemleistungen abhängig sind für Ernährung, Wirtschaft und soziokulturelles Wohlbefinden. Zudem sind die Lebensunterhaltsstrategien von indigenen und lokalen Bevölkerungsgruppen durch soziopolitische und ökonomische Erschütterungen und Umbrüche unter Druck.

Diese Dissertation hat zum Ziel, die Verwundbarkeit und Anpassungsfähigkeit des arktischen sozio-ökologischen Systems zu analysieren. Dazu untersucht die Arbeit indigenes und lokales Wissen über die Treibkräfte des globalen Wandels und ihrer Auswirkungen auf das sozio-ökologische System. Sozio-ökologische Systeme stellen komplexe Interaktionen zwischen Mensch und Natur dar. Durch beschleunigten globalen Wandel kann die Verwundbarkeit von sozio-ökologischen Systemen erhöht und dadurch ihre Nachhaltigkeit gefährdet werden. Die Dissertation basiert auf zwei Fallstudien im arktischen Gebiet der Republik Sacha (Jakutien) in Nordostsibirien, Russland, wo Mitglieder von indigenen (Eveny, Evenki, Sakha) und nicht-indigenen Gemeinschaften (Russen, Ukrainer etc.) interviewt wurden. Die Arbeit verwendet einen „mixed methods"-Ansatz: in vier arktischen Siedlungen wurden 34 qualitative Interviews, teilnehmende Beobachtung, zwei Fokusgruppen-Diskussionen und 204 quantitative standardisierte Befragungen durchgeführt.

Die Studie hat gezeigt, dass jakutische Gemeinschaften vielfältigem, von globalem Wandel verursachten Stress ausgesetzt sind. Dieser Stress hat einen erheblichen Einfluss auf die Lebensunterhaltsstrategien von indigenen und lokalen Bevölkerungsgruppen und deren traditionelle Praktiken (Jagen, Fischen, Sammeln und Rentierhaltung). Als Folge davon ist die Ernährungssicherheit von indigenen und lokalen Bevölkerungsgruppen in Frage gestellt. Indigene und lokale Gemeinschaften haben Anpassungsstrategien zum sich verändernden Klima und der Umwelt entwickelt (veränderte Fischgründe bei Fischknappheit, Änderung von Konsumgewohnheiten, usw.). Ihr Anpassungspotential ist allerdings durch soziopolitische und ökonomische Veränderungen (z.B. der Zusammenbruch der Sowjetunion oder neue Fischereigesetze) eingeschränkt.

Das Zusammenspiel des erwähnten klimatisch bedingten Stresses mit soziopolitischen Umbrüchen und Trends erhöht die Verwundbarkeit der Lebensunterhaltsstrategien von lokalen und indigenen Gemeinschaften. Um die Nachhaltigkeit des arktischen sozio-ökologischen Systems zu erhalten oder zu vergrössen, ist es deshalb notwendig, indigenes und lokales Wissen in die Entwicklung und Umsetzung von Naturschutzmassnahmen einzubeziehen.

Резюме

В Арктике наблюдаются стремительные трансформации в результате глобальных изменений в окружающей среде. Эти изменения значительно воздействуют на биоразнообразие и функционирование экосистемы Арктики: изменение климата приводит к сдвигам ареала животного и растительного мира; землепользование и технологическое развитие вызывают изменения миграционных путей большого количества животных; вторжение инвазивных видов вытесняет аборигенные виды; и перепромысел приводит к исчезновению многих аборигенных особей. Коренные жители Арктики так же подвергаются глобальным изменениям окружающей среды, поскольку их питание, промысел и социально-культурное благополучие напрямую зависят от состояния биоразнообразия и природных ресурсов. Более того, жизнь и быт коренных народов усложняются социально-политическими и экономическими стрессами и шоками.

Целью данной диссертации является оценка уязвимости и адаптивной способности социально-экологических систем Арктики. Для этого было изучено традиционное знание коренных народов и местных жителей о факторах глобального изменения окружающей среды, воздействующих на социально-экологичнские системы. Социально-экологические системы представляют собой взаимодействия человека с его окружающей средой. В случае усиления глобальных изменений окружающей среды, уязвимость социально-экологических систем может возрасти, и тем самым может поставить под угрозу их устойчивость. Диссертация основана на практическом анализе (кейс-стади) в четырех районах Республики Саха (Якутия) в Северо-Восточной Сибири, Россия, в которых были интервьюированы коренные (эвены, эвенки, якуты) и некоренные (русские, украинцы и др.) народы. Был использован смешанный метод, при котором были проведены 34 качественные глубинные интервью, включенное наблюдение, две фокус группы и количественное стандартизированное анкетирование (204 шт.) в четырых населенных пунктах в Арктических улусах Якутии.

Исследование показало, что жители Якутии испытывают множественные стрессы, связанные с глобальным изменением окружающей среды. Эти стрессы значительно влияют на жизнь и быт коренных народов и местных жителей, а также на традиционные виды хозяйствования (охота, рыбалка, собирательство и оленеводство). Продовольственная безопасность коренных народов и местных жителей может оказаться под угрозой вследствие этих стрессов. Коренные народы и местные жители разработали свои адаптивные стратегии к меняющимся климату и окружающей среде (смена места рыбалки в случае недостатка рыбы, смена привычки потребления и др.). Однако, адаптационный потенциал ограничен социально-политическими и экономическими трансформациями (например, распад СССР или новые законы о

рыболовстве). Взаимодействие этих климатических стрессов и социально-политических шоков и трендов повышают уязвимость жизни и быта коренных народов и местных жителей Арктики. Поэтому, в целях поддержания или повышения устойчивости социально-экологических систем Арктики, необходимо учесть традиционные знания коренных народов и местных жителей в ведении природоохранной политики.

Кылгас тумук

Тулалыыр айылҕаны харыстаабат буолууттан, Арктикаҕа тосту уларыйыылар тахсаллар. Глобальнай уларыйыы Арктика биологическай эгэлгэтигэр уонна экологическай системэтигэр улаханнык дьайар: килиимэт уларыйыыта элбэх үүнэйилэр уонна харамайдар өрүт эйгэлэриттэн куоталларыгар күн эллэр, сири туһаныы уонна технологическай сайдыы сорох харамайдар көнөр суолларыгар мэһэйи үөскэтэр, туора дойду хамсыыр-харамайа кэлиитэ төрүт хамсыыр-харамайы куоттарар, сиэрэ суох бүлүннэрэ төрүт хамсыыр-харамайы мэлитэр. Арктикаҕа өрүт олохтоохторугар маннык глобальнай уларыйыылар эмиэ дьайыылаахтар, тоҕо диэтэр кинилэр олохторо-дьаһахтара, астара-үөллэрэ, өй-санаа баайа тулалыыр эйгэттэн тутулуктаах. Онуһ та ынан, социальнай-политическай уонна экономическай истириэстэр Арктика төрүт олохтоохторун дьаһахтарын ыарырҕатар.

Бу чинчийии сыалынан-соругунан социальнай-экологическай системэлэр эмсэҕэйиилэрин уонна адаптацияланар кыахтарын сыаналаһын буолар. Ол туһугар төрүт олохтоохтор айылҕа глобальнай уларыйыылара социальнай-экологическай системэҕэ дьайыыларын туһунан билиилэрин үөрэтии буолар. Социальнай-экологическай системэ диэн дьон айылҕаны кытта ситимэ буолар. Айылҕаҕа күүстээх глобальнай уларыйыылар тахсар тугэннэригэр, социальнай-экологическай системэ эмсэҕэлээһинэ күүһүрэр, онон туруктаах буолууга куттал үөскэтэр. Чинчийии Саха Сирин икки оройуоннарыгар төрүт (эбээннэр, эбэҥкилэр, сахалар) уонна кэлии (нууччалар, украинецтар уо.д.а) омуктары кытта ыытыллыбыт интервьюларга тирэҕирэр. Ол курдук, 34 интервью, 204 ыйытыннаьык, кэтээн-көрүү уонна икки фокус-группа 4 хоту улууһун нэһилиэктэригэр ыытыллыбыттара.

Чинчийии көрдөрбүтүнэн Саха Сирин олохтоохторо айылҕалуларыйыытын кэтээн көрөллөр эбит. Ол уларыйыылар олоххо-дьаһахха, бултка-алтка куһаҕан дьайыылаахтар. Ону таһынан ас-үөл кэбирэх буолуута үксүгүн сөп. Төрүт олохтоохтор килиимэт уонна айылҕа уларыйыыларыгар адаптацияланарга бэйэлэрэ туспа ньымалардаахтар (холобура, балык суох буоллаҕына, балыктыыр сирдэрин уларытыы эбэтэр атын аска өһүү). Ол гынан баран, адаптацияланар кыахтара социальнай-политическай уонна экономическай уларыйыылартан хааччахтанар (Сэбиэскэй Сойуус эстиитэ эбэтэр балыктааһыны бобуу). Килиимэт уларыйыыта ону тэҥэ социальнай-политическай истириэстэр холбоһо он дьайыылара Арктика төрүт норуотун олоҕун-дьаһаҕын кэҕиннэрэр. Онон сибээстээн, Арктика социальнай-экологическай системэтэ тирэхтээх буоларын хааччыйарга, ону таһынан айылҕаны харыстыыр бэлитиикэни ыытарга, төрүт олохтоохтор билиилэрэ учуоттаныахтаах.

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Content

List of abbreviations

ASSR: Autonomous Soviet Socialist Republic

ATV: All-Terrain Vehicle

C: Carbon

CBD: Convention on Biological Diversity

DFID: Department for International Development

GHCN-D: Global Historical Climatology Network-Daily

GHG: Greenhouse Gas

ICARP III: International Conference on Arctic Research Planning

IK: Indigenous Knowledge

IKS: Indigenous Knowledge System

IPCC: Intergovernmental Panel on Climate Change

KNMI: Koninklijk Nederlands Meteorologisch Instituut (Royal Netherlands Meteorological Institute

NTFP: Non-Timber Forest Products

RCP: Representative Concentration Pathways

SESs: Social-Ecological Systems

SLA: Sustainable Livelihoods Approach

SLF: Sustainable Livelihoods Framework

SPSS: Statistical Packages for Social Sciences

TEK: Traditional Ecological Knowledge

UNDP: United Nations Development Program

USSR: Union of Soviet Socialist Republics

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1 Vulnerability of Social-Ecological Systems in the Arctic

1.1 Introduction

The Arctic (including the sub-Arctic)[1] is facing drastic challenges due to global change. The most pronounced global change driver in the Arctic is climate change with a temperature increase twice as high as on global average – a phenomenon called Arctic amplification (Cohen et al., 2014). As a consequence of climate change, the Arctic is experiencing major changes in its ecosystems, including the immigration of southern species (Walther et al., 2009). In addition, the Arctic region is encountering habitat changes, contamination and overexploitation (Millenium Ecosystem Assessment, 2005) causing undesired challenges for Arctic livelihoods such as the decline of natural resources or cultural loss. These global change drivers also may affect traditional food security of local and indigenous communities as a result of the reduced availability of natural resources (Brander, 2010). Understanding the response of Arctic social-ecological systems to global change is crucial because local communities and their livelihoods are highly dependent on ecosystem goods and services (benefits derived from the ecosystems) for food, clothing, shelter and spiritual wealth (Berkes, 1998; Nuttall et al., 2005). However, global change may also open up opportunities for some stakeholders. Climate change may provide better access to remote areas and is economically beneficial for shipping and industrial development (Hovelsrud et al., 2011).

Research of social-ecological systems entails the analysis of adaptive capacity, resilience, robustness, stability, sustainability, transformability and vulnerability (Cox, 2010; Dong et al., 2016). These terms are employed differently in the literature: some authors use the terms interchangeably (Levin and Lubchenco, 2008; Newman, 2003), others in a contradictory manner (Carpenter et al., 2001; Folke, 2006). Levin and Lubchenco (2008) do not distinguish resilience from robustness and define them as a "capacity of a system to absorb stresses and continue functioning" (Levin and Lubchenco, 2008: 28). Folke (2006) describes robustness as an inherent part of resilience, but not as similar concept. In this thesis I will focus on the concepts of vulnerability and adaptive capacity. Indigenous communities are especially vulnerable to global change as they 1) often inhabit ecosystems which are susceptible to climate change effects; 2) are dependent upon natural resources for livelihoods; and 3) are often among the poorest and most marginalized populations (Ramos-Castillo et al., 2017). Therefore, it is crucial to analyse vulnerability and adaptive capacities of indigenous people. In addition, "understanding vulnerability and resilience of Arctic environments and societies and supporting sustainable development" is one of the key topics of the latest International Conference on Arctic Research Planning (ICARP III) report published in 2016.

[1] "The region encircling the North Pole is called the Arctic Circle, an invisible circle of latitude (imaginary line around the Earth parallel to the equator at 66°33' North. The arctic region sits inside the Arctic Circle and the subarctic region lies just below it." (www.encyclopedia.com)

1.2 Background and state of the art

This subchapter presents concepts of Social-Ecological Systems (SESs), the Sustainable Livelihood Approach (SLA), which addresses vulnerability and adaptive capacity. It also introduces an intergated concept of SESs and SLA and reviews the literature relevant to the research topic.

1.2.1 Social-ecological systems (SESs)

Anderies et al. (2004: 3) define SESs as social systems "in which some of the interdependent relationships among humans are mediated through interactions with biophysical and non-human biological units". The social-ecological systems (SESs) concept is an approach to describe the relations between humans and nature. It implies that human and nature are interdependent, therefore "any distinction between social and ecological systems is arbitrary" (Adger, 2006: 268). A crucial element of the interactions in SESs are the positive and negative external factors created by actors by the virtue of either utilizing a resource or providing resource infrastructure. The framework of SES has been widely used by Anderies et al., (2004), Gunderson and Holling (2002), Janssen et al. (2006), however, as an entry point for this thesis, I will employ a general framework developed by Ostrom (2009).

The SESs framework as formulated by Ostrom uses a tiered approach to analyze the components and sub-components of complex SESs. She identifies four main components: 1) resource system, 2) resource units, 3) resource users, and 4) governance system. These components interact in a specific social-political setting and related ecosystems to achieve certain outcomes. Accordingly resource users consume resource units from a resource system. The resource users also provide resource infrastructure according to the rules and norms defined by a governance system and in a certain ecosystem and social-political setting. The resource consumption and resource infrastructure are important forms of interactions and outcomes (Ostrom, 2009). There are also sub-components, which constitute characteristics of the components such as size (size of resource system), type (sector of resource system (fish, pasture etc.)), value (economic value of resource unit) and so forth. In turn, aforementioned sub-components consist of their own sub-components which indicate attributes of the former (e.g. geographic expansion, number of interacting species) (McGinnis and Ostrom, 2014).

In this thesis *resource systems* entail tundra and river environments; *resource units* include natural resources (e.g. fish, reindeer, berries); *users* are represented by the Arctic indigenous and local communities of fishers, hunters, gatherers and reindeer herders; the *governance system* implies current governmental regulations and laws (e.g. fishing regulations); the *social-political setting* entails the post-Soviet transitional regime; *related ecosystems* indicate climatic and environmental conditions; interactions are traditional

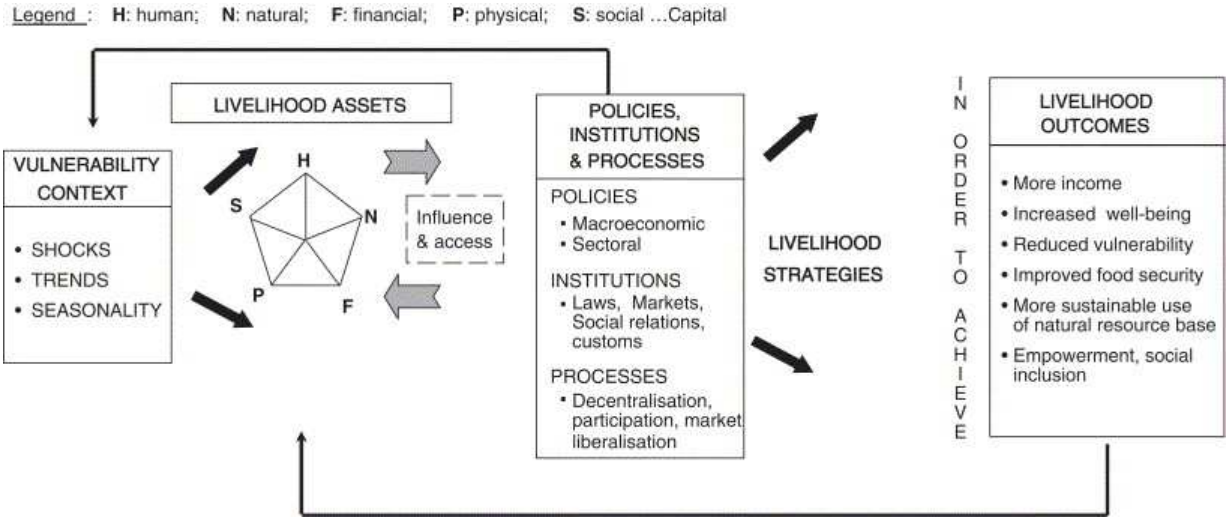
practices of harvesting natural resources or adaptive strategies; and, finally, outcomes imply achieved sustainability or well-being.

One of the critiques of the social-ecological concept is its lack of historical context. Even though the concept recognizes temporal cross-scale connections, it often narrows down the focus to current conditions (Widgren, 2010). Naumann (2017) postulates that a research, which attempts to comprehend a status-quo of social-ecological systems must take into account past dynamics of the systems. Widgren (2012) criticizes the concept for being reductionist in differentiating social and ecological systems. Social systems significantly vary from ecological systems in their complex structure since they are characterized by power relations and human intentions. In addition, the social-ecological systems concept "tends to subordinate the humanities and social sciences to an epistemology and ontology based on the natural sciences" (Widgren, 2012: 120). While concentrating in this thesis mostly on current issues and potential future developments, historic aspects are addressed as well (namely regarding the political context in Soviet and post-Soviet times). Moreover, by relying on social scientific methodology and looking at SES from the perspective of the respondents and by using the SLA I try to avoid a positivistic stance.

1.2.2 Sustainable Livelihoods Approach (SLA)

The concept of sustainable livelihood has become widespread after the release of the Brundtland Report in 1987 where it was defined as follows: "livelihood is defined as adequate stocks and flows of food and cash to meet basic needs. Sustainable refers to the maintenance and enhancement of resource productivity on a long-term basis" (UNWCED, 1987). However, the concept gained ground after the publications of scholars (Chambers and Conway, 1992; Scoones 1998) and practical applications of development agencies such as CARE, Department for International Development (DFID), United Nations Development Program (UNDP). According to an adapted definition of DFID "a livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets, both now and in the future, while not undermining the natural resource base" (DFID, 2002). The DFID depicted the framework in a schematic figure shown below (fig.1)

Figure 1: Visualization of the Sustainable Livelihoods Approach. (DFID, 2002).



The vulnerability context implies risks to livelihood assets (i.e. the five capitals mentioned in the framework). These risks are associated with natural, socio-political and economic factors limiting or expanding access to assets. Livelihood assets – people's capitals for sustaining life – comprise of natural (i.e. access to land or provisioning ecosystem services), social (i.e. a network to rely on), human (i.e. knowledge, health), physical (i.e. buildings, vehicles, appliances) and financial (i.e. savings, cash income) resources. Transforming structures and processes refer to rules (i.e. laws), norms (i.e. cultural customs), policies (i.e. a government's plan to adapt to global change impacts) and regulations (i.e. fishing or hunting regulations) determining livelihoods. Livelihood strategies indicate available livelihood options to achieve livelihood outcomes, which ought to increase people's well-being, adaptive capacity, sustainability without deteriorating their natural resource base. In the scope of this thesis, I will not place an emphasis on all capitals, but only on the most relevant ones. A more detailed overview of the combined concepts of SLA and SESs will follow in the upcoming subchapter.

One of the core principles of the SLA is its anthropocentric nature. It places people's livelihoods at the core of the framework prioritizing people rather than the resources they utilize (DFID, 2002). SLA is participatory, directly involves stakeholders and its implementation is difficult without a "bottom-up" approach (Morse and McNamara, 2013). Moreover, the framework takes into consideration knowledge systems of local people, which is crucial in the assessment of Arctic communities. Another important principle of the SLA consists in its holistic character. It views people's livelihoods as a whole, with all their multiple aspects regardless of the scale, sector, or space (DFID, 2002). It is especially relevant in resource-dependent livelihoods (e.g. of the Arctic) where people may have several livelihood contributions rather than a single income (Tao and Wall, 2009).

SLA has been criticized for several shortcomings. Within the scope of this thesis, I will mention those, which are relevant to this study. Reed et al. (2013) criticize the framework for emphasizing stocks of natural capital and not flows of ecosystem services that those capitals deliver. Climate change may alter the flow of ecosystem services, however without entirely changing stocks of natural capital (Reed et al., 2013). For example, it may be possible to conserve stocks of native resources in an Arctic tundra under climate change with non-native resources better adaptable to new climatic conditions, however this may result in the decline of provisioning and cultural ecosystem services from the tundra. In the SLA attention is focused on local capacities and knowledge of coping with short-term shocks and stresses. However, when it comes to longer-term climatic changes, such local strategies are not enough (Scoones, 2009). Here, the a-historicity of the SLA that is often criticized becomes apparent (Geiser et al., 2011). Therefore, it is vital that sustainability is achieved not only through local adaptation, but also in response to long-term transformations.

1.2.3 Vulnerability

Global environmental change is compromising people's livelihoods. People are also experiencing social, political and economic transformations. The interplay of both changes may increase or decrease the vulnerability of livelihoods. Therefore, to lessen the potential damage of global change, humans need an accurate vulnerability assessment of social-ecological systems in which they live, and of adaptive capacities and constraints derived from global change (Schröter et al., 2005).

Vulnerability implies "the degree to which a system is likely to experience harm due to exposure to a specified hazard or stress" (Chapin et al., 2009). The concept of vulnerability is a substantial analytical tool for elucidating conditions of susceptibility to harm, debility, and marginality of social-ecological systems, and for normative analysis of measures to improve well-being by reducing risk (Adger, 2006). Pivotal elements of the vulnerability analysis are the potential risks (climate change) and endowments (assets) affecting livelihoods and well-being. Etzold and Sakdapolrak (2016) argue that it is necessary to engage a notion of space and spatiality for vulnerability analyses and assess four key socio-spatial relations: place, network, territory and scale (Etzold and Sakdapolrak, 2016). Watts and Bohle (1993) state that vulnerability is shaped by three components – exposure to shock, capacity to recover from shock, and potentiality of serious implications from shock. Therefore, a feedback to vulnerability is to "reduce exposure, enhance coping capacity, strengthen recovery potential and bolster damage control via private and public means" (Watts and Bohle, 1993). Ford and Smit (2004) similarly conceptualize vulnerability as a combination of three components: exposure and sensitivity to climatic risks, as well as adaptive capacity to cope with these risks. Exposure and sensitivity denote susceptibility of an individual or

groups to risks associated with ecological conditions, and adaptive capacity indicates an individual's or groups' ability to deal with or adapt to exposure and sensitivities (Ford and Smit, 2004).

Research on climate change vulnerability and adaptive capacity in Russia is limited (Mcdowell et al., 2016; Stammler-Gossman, 2010) and addressed only in few studies (i.e. Crate, 2008; Forbes et al., 2009; Graybill, 2015; Lavrillier, 2013; Mustonen, 2011). Vulnerability assessment in Russian case studies are challenged by the lack of own climate change vocabulary. Terms are translated from the western vocabulary and sometimes do not correspond well to Russian terms (Stammler-Gossman, 2010).

In contrast, vulnerability in the Western Arctic has been well assessed (Chapin et al., 2004; Ford et al., 2006; Himes-Cornell and Kasperski, 2015; Keskitalo, 2010; Tyler et al., 2007). Ford et al. (2006) apply the vulnerability framework in two stages through the lens of exposure-sensitivity and adaptive capacity. The first stage assesses present and past knowledge and observations of local people of climate change in order to build a baseline for future actions. The second stage examines future vulnerability, sensitivity-exposure and adaptive capacity based on the past experience. In their case study in Arctic Bay, Canada, Ford et al. (2006) reported that Inuit harvesting practices and livelihoods are vulnerable to environmental and climatic changes which limit access to hunting grounds, make hunting dangerous and affect traditional food security. Tyler et al. (2007) analyzed the vulnerability of Saami reindeer herders of Finnmark, Norway, based on a framework consisting of three parts: 1) climate projections and ecological implications of climate change, 2) coping and 3) limitations of coping. The analyses revealed that the vulnerability of Saami herders is increased mostly by non-climate factors such as loss of habitat, predation by large mammals as well as governance (regulation of rights of pasture, of the ownership of animals, market and price control, legislative protection of predators).

Stammler-Gossman (2010) states that Nenets of the Russian Arctic perceive vulnerability to environmental changes as "the autonomy and self-organization of nature". They are more concerned and perceive themselves as vulnerable to anthropogenic disturbances such as industrialization. Graybill (2015) reports that urban settlements in the Russian Arctic are vulnerable to climate change due to a combination of different factors such as permafrost thawing, ground subsidence, industrial pollution, infrastructure aging, in-migration, lack of well-developed regional and local policies of climate change.

The concept of vulnerability has been criticized for an exaggerated emphasis on the anthropogenic origin of hazards. Brookfield (1999) argues that in the 1980s and 1990s, there was a tendency to relate anthropogenic causes of hazards to natural ones which has deprived the importance of biophysically produced causes. He states that most hazards originate from a complex interplay of anthropogenic and biophysical causes (Brookfield, 1999). The

vulnerability concept does not require or provide the conceptual tools for distinguishing, classifying and prioritizing causal factors. Therefore, it is difficult to establish which shocks are probable, and which individuals or groups could be exposed, their different levels of susceptibility and the possible outcomes (Dilley and Boudreau, 2001). In this thesis, I do not distinguish and classify factors affecting livelihoods, but rather address them as an interplay of equal factors.

1.2.4 Adaptive capacity

The Intergovernmental Panel on Climate Change (IPCC) defines adaptive capacity as "the ability of systems, institutions, humans and other organisms to adjust to potential damage, take advantage of opportunities, or to respond to the consequences" (IPCC, 2014). Adaptive capacity assessment aims at facilitating positive practical action to increase the ability of a certain system to adapt to changes (Whitney et al., 2017). Since this thesis addresses social-ecological systems, it is worthwhile to define adaptive capacity in social and ecological systems separately. In ecological systems, adaptive capacity indicates that species or ecosystems have the innate ability to endure over time and through change (Smit and Wandel, 2006). In social systems, adaptive capacity entails the capability of humans to increase the quality of life in a specific environment (Gallopín, 1989). While ecological systems respond to stresses purely reactively, social systems respond both reactively and proactively (Smithers and Smit, 1997). Adaptive capacities of coupled social-ecological systems depend on the duration and severity of the stress. Both social and ecological systems might quickly adapt to a short-term stress lasting one or two years, while for long-term stresses, such as globalization processes or climate change, it might take longer for social-ecological systems to adapt (Perry et al., 2011). The ability of the system to adapt is affected by the drivers of adaptive capacity (Adger, 2003; Smit and Pilifosova, 2001). At the local level adaptive capacity is influenced by drivers such as managerial ability, access to financial, technological and information capitals, infrastructure, political impact, kinship networks (Smit and Pilifosova, 2001). Some drivers of adaptive capacity are mostly local whereas others represent more common socio-economic and political systems (Smit and Wandel, 2006). The adaptive capacity drivers are dependent upon each other and their functioning depends on the context. For example, a strong kinship network provides better access to economic resources and thereby increases adaptive capacity. Or, the kinship network plays a crucial role in an indigenous community (by prey sharing, for example), however, has a quite different effect in a Western context (Smit and Wandel, 2006).

The adaptive capacity of Western Arctic social-ecological systems is well covered in the literature (Bunce et al., 2016; Dannevig et al., 2015; Reed et al., 2014; Tiller et al., 2016), however the knowledge about the Russian Arctic, and especially the Yakutian Arctic, is

limited. In Finland and Sweden, the adaptive capacity of reindeer herders is constrained by economic and political conditions, e.g. herding is dependent on money due to mechanization and supplementary feeding, and the hunt of reindeer by predators is regulated by the legislation (Heikkinen et al., 2012). Similarly, the adaptive capacity of Canadian Inuit communities is restricted by economic conditions. Lack of financial capital limits local people's capacity to deal with climatic and environmental changes (Andrachuk and Pearce, 2010).

However, despite these constraints, Arctic local people have been successfully adapting to climate change. Norwegian fishers adapt to warmer ocean temperatures and the associated altered distribution and abundance of fish stocks by catching different fish species, changing fishing grounds, extending working time as well as practicing tourism to diversify income (Hovelsrud et al., 2010). Inuit communities in Canada employ new equipment or new trail networks in order to keep up traditional hunting activities which are challenged by sea ice dynamics, fluctuating wind patterns, and changing migration habits of animals (Ford and Furgal, 2009). Nenets reindeer herders in Russia search for better pastures in case of the formation of ice crusts hindering reindeer forage access, in the event of heavy snowfall, herders find places well protected from snow and wind such as holes, river banks or mountainsides (Bulgakova, 2010). In the Soviet Union the adaptive capacity of the indigenous communities was better due to governmental subsidies. Subsidies played an important role in adapting to socio-economic and political transformations after the Soviet regime collapse. Thus, the decline of reindeer herding on the Kola Peninsula was less dramatic as the regional authorities were able to subsidise local reindeer herders (Rees et al., 2008). Even though the subsidy system has become an important income source for many Sami reindeer herders in Western Norway, it threatens traditional Sami knowledge of pastoralism to erode over time since the economic incentives encouraged many pastoralists to adopt the state governance system (Johnsen et al., 2017).

1.2.5 Integration of SES and SLA

Assessing livelihoods from the social-ecological systems perspective helps to analyse the interrelations of people and their biophysical environment as well as institutions (that govern people and environment) to sustainably support livelihoods in a complex and dynamic setting. If the SLA brings to the forefront people's livelihoods, SESs depicts intricate interactions of people and the environment. Therefore, in this thesis I incorporate core ideas of both approaches to better understand livelihoods in complex social-ecological systems.

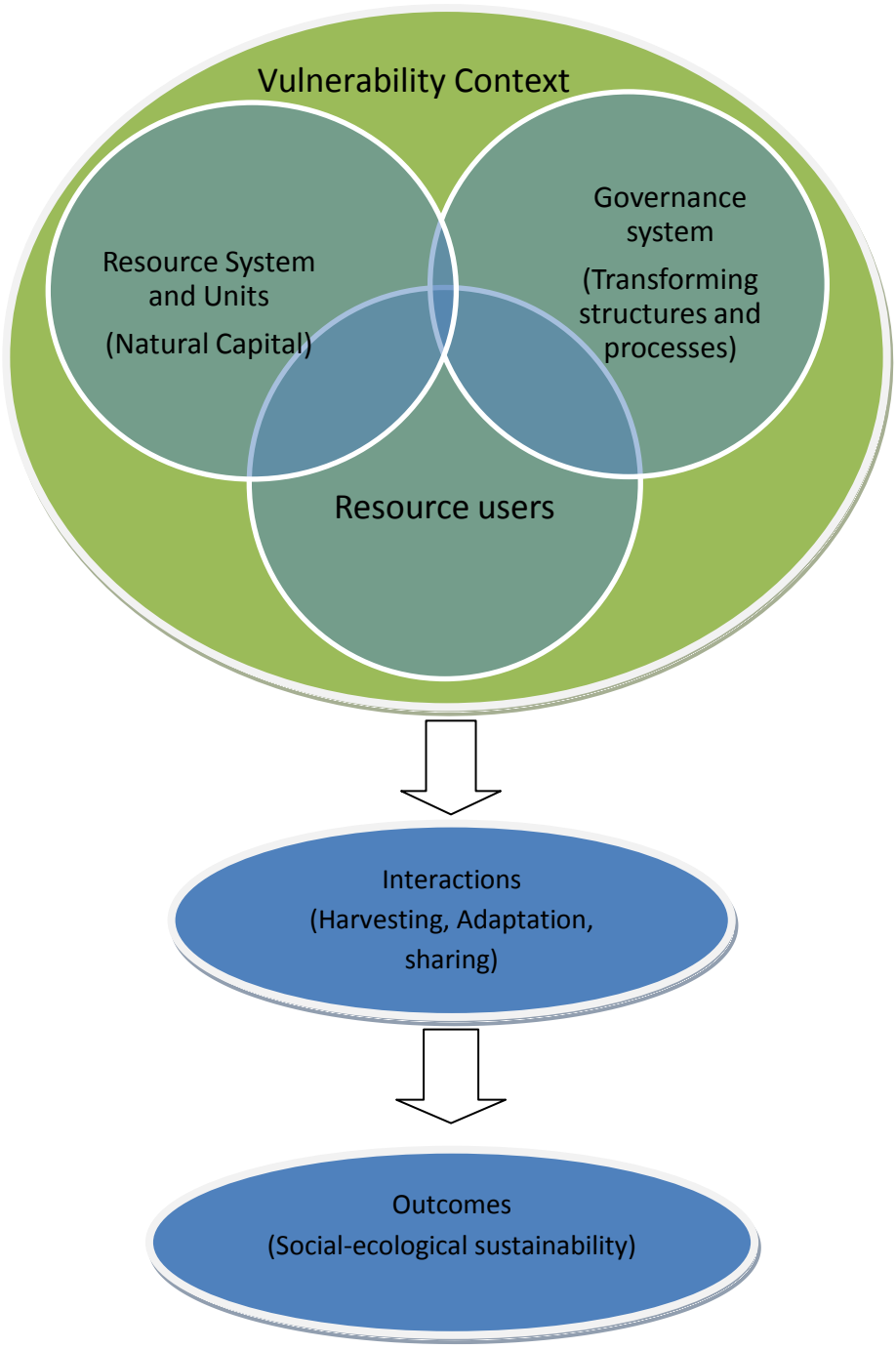
This thesis acknowledges vulnerability as being an integrated frame, which links the concepts of sustainable livelihood and social-ecological systems within which an assessment of human-environmental interactions is carried out. An adapted framework serves as an

underlying tool for the analysis of factors affecting the vulnerability of local livelihoods and the resource system of the Arctic to global change. Hence, an adapted framework combines anthropocentricity and comprehensiveness of the SLA with the more holistic approach of SESs to address the inherent complexity and vulnerability of human and ecological systems.

The core components of the adapted framework are represented by three variables: resource systems and units, resource users and the governance system. All three components of this SESs interact with each other and directly or indirectly influence one another. For example, fishers (resource users) catch their fish (resource unit) in the river (resource system), however fishing regulations (governance system) restrict fishers by imposing quotas or other limitations. I have combined resource system and resource units in one component since they are assessed as integral in the context of this thesis and are viewed as natural capital from the SLA perspective. Moreover, indigenous peoples perceive the environment with all its animals and plants as an integral entity. Resource users denote resource-dependent communities of the Arctic and also include social as well as human capitals. Social capital as seen by the SLA means "the social resources upon which people draw in pursuit of their livelihood objectives" (DFID, 2002). Within the scope of this thesis, this may encompass kinship, prey sharing, social and spiritual cohesion. SLA defines human capital as "the skills, knowledge, ability to labour and good health that together enable people to pursue different livelihood strategies and achieve their livelihood objectives" (DFID, 2002). It may embrace indigenous knowledge, cosmologies, hunting or fishing skills. The adapted framework integrates the governance system as policy, rules and regulations in terms of national legislation, public policies, subsidies provided, monitoring and sanctioning mechanisms as well as cultural norms and customary laws. It therefore serves as transforming structures and processes as viewed by the SLA. Rules should conform local conditions, otherwise sustainability in the long-run perspective may not be gained (Ostrom, 2009). For example, climatic and environmental conditions of one specific Arctic region may differ from others in space and time, consequently, regulations established across regions may not be congruent with these specific conditions. The interactions of the components take place in an environment which comprises of external shocks, trends and seasonalities that affect all the components of the social-ecological system. Climate change related trends may cause species (resource unit) extinction, which in turn increases vulnerability of people's (resource users) livelihoods. The governance system may be affected by the political shocks such as the USSR collapse, or trends such as market prices. However, not all elements of the governance system are impacted by the vulnerability context, especially at the level of formal legislation. In case of shocks, resource users or units may take adaptation actions for the better outcomes of social-ecological well-being and sustainability. However, governmental restrictions may limit these actions, then vulnerability of the livelihoods will increase.

Strong reliance on natural resources results in a greater effect on community well-being in the context of environmental change (Bene et al., 2000). Moreover, resource-dependent communities are more vulnerable in the face of socio-political transformations. Therefore, it is essential to understand the vulnerability context of socio-political systems to global change. The integration of both approaches is visualized in the figure below (Fig. 2).

Figure 2: Integrated framework of Social-Ecological Systems and Sustainable Livelihoods Approach.



1.3 Methodology and research sites

It has been suggested that issues of indigenous people should be assessed by indigenous people employing indigenous methodologies (Kahakalau, 2004). When a research is carried out by an indigenous person, it undergoes a significant transformation compared to when research is performed from an outside perspective: questions are formulated in a different way, priorities are rated differently, issues are described differently (Smith, 1999). This leads to the design of a novel, culturally suitable indigenous methodology that in the best case warrants success, positive results and prompt benefits for the community involved (Kahakalau, 2004). The downside of doing research in one's own ethnic group and the sharing of cultural values could be a blindness for certain "obvious", or "natural" aspects that can be described as going (or being) native. Hence, an indigenous research must find a balance between closeness and detachment that allows a critical assessment of one's research.

Despite my positionality as a member of the Sakha ethnic group, inhabitant of Yakutia and fellow Russian citizen I do not automatically understand all issues indigenous people may have. However, due to my socialisation and proximity to the processes they face I was confident to be able to quickly and adequately relate to my interview participants, their problems and views. Even though my hometown is a small town further South and I rarely ventured to the Arctic North, I was able to quickly gain access and trust during my fieldwork, which an outsider from further away would probably had more difficulties with. The fact that I did not grow up amidst Arctic people though, helped to critically deal with what was said and done by my respondents. However, it is sometimes difficult to be "insider", because one may have a bias in personal attitude, therefore I have designed my research in such a way that I did everything to exclude (or minimize) my bias with appropriate research methods.

1.3.1 Methods

Indigenous methodologies are alternative reflections on a research. They aim at assuring research performance in a way that it is favourable, respectful and ethically accurate from an indigenous perspective (Louis, 2007). According to one of the definitions "indigenous methodology is a body of indigenous and theoretical approaches and methods, rules and postulates employed by indigenous research in the study of indigenous peoples. The main aim of indigenous methodologies is to ensure that research on indigenous issues can be carried out in a more respectful, ethical, correct, sympathetic, useful and beneficial fashion, seen from the point of view of indigenous peoples" (Porsanger, 2004: 107-108). Thus, an indigenous approach to a research significantly varies from the one of non-indigenous. Louis (2007) distinguished four differences between indigenous and non-indigenous methodologies: 1) acceptance of indigenous knowledge system (IKS). IKS sometimes enormously differs from scientific knowledge in many ways with respect to context, roots, rhetoric, metaphysics,

narratives and spirituality. Understanding as well as interpreting all these attributes is quite challenging, therefore incorporating indigenous views is necessary. 2) Acknowledgement of indigenous people as collaborators rather than "subjects" or informants, which is quite common in non-indigenous research. 3) Designation of a research agenda based on a real (and honest) interest rather than funding possibilities. 4) Sharing knowledge of the (past) research with involved indigenous people.

I have not employed indigenous methodology consistently in my research (as far as it was possible I adhered to the points 1-3 and I aim to share the gained knowledge once being back to Yakutia), however I consider being an indigenous person and interviewing indigenous people helps to better access and understand them. First of all, speaking a common language is an ideal situation (Smith, 2016) since differences in language may cause misunderstandings in concepts, especially in a qualitative inquiry as it deals with words: language is key in all stages from data collection and analysis to publication (van Nes et al., 2010). During data analysis I have encountered minor issues of translating phrases associated with "doing something" which strongly depend on a context. For example, responses of many interviewees would be translated into English as "I did that after having done this while doing that", however the meaning of the phrase will depend on the previous quote or question. Moreover, some indigenous languages count for only few and there are no learning resources, hence it is quite challenging to master them. Secondly, conducting research as an indigenous person or so called "insider" "enhances the depth and breadth of understanding a population that may not be accessible to a non-native scientist" (Kanuha, 2000: 444). Thirdly, many indigenous communities express distrust to "outsider" researchers amid historical facts of distress and exploitation (Burnette and Sanders, 2014). This can be an obstacle to carrying out research with indigenous people.

This thesis is based on a mixed methodology approach: semi-structured qualitative in-depth interviews (34), focus group discussions (2), participant observation and a quantitative survey (204). A mixed method approach allows researchers to answer a more extensive array of research questions and collect high-quality and rich data which is less possible using single methods (Yin, 2014). The analytical part of the research is based on content analysis using MaxQDA and descriptive statistics with SPSS software. This subchapter highlights each of the methods employed.

The first phase of the research was carried out in summer of 2014 using *semi-structured in-depth interviews* (Taylor-Powell and Renner, 2003) with indigenous people. The number of people involved in interviews in three research sites equals 34. The selection of interview participants was conducted during focus group meetings with the municipal administration and elders on the first day of the field trip. Following a purposeful sampling strategy, I tried to cover all categories of indigenous people actively engaged in traditional

activities or closely tied to the natural environment, including fishers, hunters, reindeer herders, gatherers and herbalists (healers) in order to acquire more detailed information about environmental and climatic issues. I also categorized interviewees based on their age (youngsters and elders) and involvement in governmental organizations (officials) to encompass more diverse responses from the perspectives of experience and engagement. The sample included twelve male and twenty two female interviewees. The interviews aimed to find out the perceptions of the indigenous people of their harvesting activities, their environment, observed climatic and environmental changes as well as adaptive strategies. Appendix I outlines interview guidelines and questions.

Respondents were interviewed in their daily setting: at home, at the office or during events. Interviews always started with the brief introductions of the research and oral agreement for interviewing and recording. Interviewees usually easily fell into conversation, and interviews lasted between half an hour to one and half hour depending on the availability of the respondents. All interviews were held in Russian or Sakha depending on participants' language proficiency or preference. Pictures of interviewees were taken after every interview, though some respondents were not keen to be photographed (people depicted on photos used in publications gave their consent). I ensured anonymity to all interview participants and picture use only for research purposes.

In general, I have not experienced any difficulties in conducting interviews. Perhaps, the insider status has helped me to gain trust among interview participants and thus provided a deeper insight into the topic. A minor problem I have encountered was the lack of time of some respondents who were busy with their duties at their jobs. Therefore, the respondents were quick with answering the questions, which might have affected the meaningfulness of some responses. Most of the interviewees were enthusiastic and active in their responses so that simple questions turned into a lively discussion. Some respondents construed me as a mediator between themselves and authorities, especially when it came to questions related to socio-political issues and asked to address these problems in my thesis to let authorities know.

Two *focus group meetings* (Flick et al., 2004) with officials and community elders were conducted in two research sites of Olenegorsk and Kyusyur which included 6 participants each. A focus group meeting was not held in Chokurdakh due to the absence of many people. The selection of the focus group participants was based on two criteria: 1) employment in the municipal administration to obtain an overview of the research site (geographical, demographic and other data), its social, political and environmental problems; 2) engagement with traditional activities such as fishing, hunting, reindeer herding, gathering and better knowledge of the natural environment to gain deeper insight into climatic and environmental changes in the area. Focus group meetings and discussions took place at the municipal offices and lasted an hour. During the focus group-meetings a list of key

informants among indigenous villagers who practice traditional activities and possibly possess a good knowledge of the environment and climatic changes was drawn up. All focus group meetings were tape-recorded and included note taking. The meetings were held in Sakha.

Even though I am an indigenous researcher, I was not familiar with the livelihoods and the overall setting of the sites, as I originate from a more Southern region. Therefore, it was helpful for me to conduct a *participant observation* (Spradley, 1980) to gain deeper insight into local livelihoods. Participant observation is often carried out by researchers dealing with indigenous communities, and it has found to be an efficient and suitable means of learning about indigenous people's livelihoods and their inherent features (Snider, 2012). I was constantly employing a participant observation method since I was staying at the host families during the field trips. We were occasionally discussing issues under research during meals or tea-breaks, strolls around the sites, events with my host-families members and their guests. I have witnessed celebrations of the Eveny summer festival *Evinek* and the Youth day in Olenegorsk, have participated in the event marking a Fishers' day in Kyusyur and was invited as a guest judge to the Nature Protection office's event for students in Chokurdakh.

In addition to qualitative interviews and observations, I performed a *quantitative survey* (Scarpa, 2012) to complement and support qualitative results with quantitative data. It is especially helpful for elucidating people's perceptions and views about social, political and environmental issues (McLafferty, 2016). It was carried out during the second phase of my field trip in the spring 2015 (April-May) at 3 sites. One site could not be reached due to an early river break up, which resulted in inaccessibility and danger of travel. The total number of questionnaires equals 204. Questionnaires were aimed to assess perceptions of indigenous and local people of their subsistence practices, observed environmental changes, political transformations, adaptive strategies and cultural ecosystem services. Questionnaires were developed in English, then translated into Russian and carried out face-to-face by the researcher. Face-to-face surveys have advantages compared to other types of surveys. They are flexible, easy to control and provide the highest response rate (Doyle, 2005). The clarity and consistency of the questionnaire were ensured during the trial survey with colleagues in order to address any issues found. The selection of the respondents followed a structured selection with the help of municipal administration employees and was based on five main categories: 1) experts (people closely tied to the natural environment and actively involved in traditional activities); 2) elder people; 3) public sector workers; 4) officials; 5) youth, who I consider as the key representatives of the research sites (or of common villages in Russia). The respondents were active and eager to fill in the questionnaires except some cases when survey participants (especially women) were not keen to answer the questions related to age or ethnicity. During the survey in Tiksi I encountered a situation when the Federal Security Service officer interviewed me about the "political questions", which turned out to be sensitive and, therefore, could potentially hurt the image of Russia worldwide. I was able to

convince the officer that with my questions I do not intend to harm Russia's reputation and was allowed to continue with the survey.

1.3.2 Research sites and area

The research sites are located in four Arctic settlements of Chokurdakh, Olenegorsk, Kyusyur and Tiksi in the North-Eastern Siberian region of the Republic of Sakha (Yakutia) in Russia. I have chosen these sites because little is known about the research topic in this area in the scientific literature, especially in English. In addition, the region is mainly inhabited by indigenous people who have been living in this area for centuries. Moreover, in recent decades the region is experiencing drastic climatic and environmental changes which significantly affect biodiversity and indigenous as well as other local people's livelihoods. Indigenous and local people's livelihoods are also tremendously impacted by the socio-political and economic transformations of the Soviet and post-Soviet regime. A detailed description of the research sites and the map are presented in Chapter 3. This subchapter presents excerpts from the diary, which I was keeping during the field trips, and where I was taking notes about the sites straight from the horse's mouth, at the libraries and during the focus group meetings.

Chokurdakh is a village with a population of about 2000 inhabitants. It used to be a navy base during the Soviet Union, and still belongs to the border zone. A key activity of its inhabitants is fishing. Fish is a very common dish in this region and one can consume it on a daily basis in every meal. After the USSR collapse Chokurdakh looks ruined and abandoned. Some previous signs of the Soviet regime are still on the walls of the buildings, even the bronze Lenin monument reminded me of that period of communism. According to statistical data there are 747 indigenous people in the Allaikhovsky *ulus* (district), who are Eveny, Yukaghirs and Chukchees. Indigenous people conflict with local officials, because their traditional lands are converted into protected areas, research stations or commercial fisheries. Now it is prohibited to fish and hunt there, which causes troubles to indigenous people's health and mental discomforts. There are quotas for fishing, however, these are considered as not high enough. The hotel's owner warned me to be very careful because of the serious criminal situation in the village, it is highly recommended not to walk alone at night and never open the door to strangers. There were even situations when criminals or alcoholics would cover as police and enter the apartment to rob.

Olenegorsk is 4 hours away, South of Chokurdakh by boat along the beautiful Indigirka river. It is an ethnic village. Olenegorsk was founded in 1972 purposefully for the development of reindeer herding and mainly comprised of inhabitants of three villages which were shut down as a result of the so-called state policy of "liquidation of unpromising villages": Oyotung, Kotenko and Ozhogino. During the Soviet Union, the village was rich and

was named as a "millionaire *sovkhoz*" which counted 28 000 reindeer heads. After the collapse and transition to a market economy, indigenous people were left alone without state support and efficient management and the *sovkhoz* was divided into *obschinas (*self-organized indigenous communities recognized under Russian Federal Law), houses were demolished, vehicles were sold and taken to Chokurdakh, reindeer numbers were reduced and nowadays the herds equal 2000 heads. It was a difficult time when alcoholism flourished, mortality sharply increased, and many families moved away. Upon arrival I could see this unfortunate picture of the village, where 50% of the houses are abandoned, almost half of the population is unemployed. Back in the Soviet days, it was prohibited to speak native Eveny, to wear traditional clothes, to hold traditional customs and ceremonies, which resulted in loss of culture. However, in the 1990s after the foundation of the association of indigenous people, traditional clothes, traditional dance "*heeje*", learning the native language and celebrating traditional festivals have been revived. I perceived Olenegorsk as the only village among all four sites where most of the villagers could speak their native language and the traditional culture and people's identification with their ethnic group was quite strong. Nowadays, the main task of the administration is to revitalise reindeer herding: pastures are registered, and infrastructure is built. The main problem now is the lack of a good transport system, which causes issues of waste disposal, delivery of agricultural products and transportation of people and goods.

I should mention that travelling to the research sites was one of the challenges I faced. First of all, some sites are located far from public transport and road infrastructure and, therefore, there is a limited means of transportation to the villages. Secondly, it is time consuming to reach the sites. For example, the only possible transport to *Kyusyur* in summer is by ship on the Lena river which took me two days. But it appeared to be a really great experience! *Kyusyur* is an ethnic settlement with a population of 1381 inhabitants (2010), 920 of whom are Evenki. The substantive activities of the settlement are reindeer herding and fishing. There is a fishing ground *Chekurovka* where many fishers and their families move to in summer. Fisheries receive quotas for fish. Some families deliver fish to these fisheries for cash or food reward. There is a refrigerator ship near the fishing ground, which buys fish from the villagers for 40-50 rubles per kg (while in Yakutsk 1 kg of fish costs up to 350 rubles). In 1977 there were 12 herds and more than 12 000 reindeer heads. However, after the USSR collapse the *sovkhoz* was split into three *obschinas* and harsh times came. Nowadays the former *sovkhoz* has one herd with 1500 reindeer heads. Transportation to the other villages is by helicopter in winter or spring and by ship in summer. Among the native Evenki families there are Koryakins, Nikitins, Tomsky, Popovs, Sleptsovs and Betyunsky families. Unfortunately, the native language was lost, today the village has only two native speakers. At the beginning of the 20th century the Soviets banned speaking native Evenk, and therefore many people switched to Sakha or Russian. Now, local authorities are trying to revive the

language, culture and traditions. Local people are dependent on fish and reindeer meat, other food products such as vegetables and dairies are less welcomed and less consumed.

Tiksi is different from the other three sites since it is mainly populated by immigrant Russians and Ukrainians who make up 53%, while the indigenous population (Evenki, Sakha) comprises 47% (personal communication with Pyotr, local resident). In addition, Tiksi is an urban settlement with key activities in shipping and aviation. It is a strategic air and sea port as well as a military base in the Russian Arctic. Fishing, hunting and gathering for most of the dwellers is a more recreational activity rather than subsistence, reindeer herding is not represented either. Tiksi has important meteorological and research stations, which cooperate with various international institutions.

1.3.3 Research aim and thesis outline

The aim of this thesis is to assess the vulnerability and adaptive capacity of Arctic social-ecological systems in the context of global change. The thesis focuses on the Arctic and sub-Arctic parts of the Republic of Sakha (Yakutia) in North-Eastern Siberia, thus contributing to close a significant research gap in vulnerability research in Arctic Russia (Mcdowell et al., 2016; Stammler-Gossman, 2010).

The specific research goals of this thesis are to

- understand the transformations of social-ecological systems due to global change,
- assess the vulnerability of social-ecological systems of Arctic Yakutia,
- examine the adaptive capacity of social-ecological systems of Arctic Yakutia to global change.

This thesis aims to answer the following research questions:

RQ1: Which changes do local people perceive in their environment and how do they relate global change drivers to perceived changes in biodiversity?

RQ2: Which global change drivers impact on the livelihoods of local people and their vulnerability?

RQ3: Which adaptive strategies are employed by the local people to cope with these impacts?

RQ4: What is being lost and revealed in the melting cryosphere and what is the impact on human relationship with the Polar regions?

My general assumptions and hypotheses are:

I. Shocks such as the breakdown of the Soviet Union, trends such as climate change or the introduction of new fishing regulations, increase Arctic peoples' vulnerability and compromise the sustainability of their livelihoods.

II. Local people are highly adaptive, however, their adaptive potential is limited by political transformations.

This thesis is composed of five chapters:

Chapter 1 provides definitions and the state-of the art of the thesis' theoretical background, and presents its objectives and research questions. Furthermore, it highlights the methods and introduces the research areas.

Chapter 2 assesses indigenous knowledge about climate, environment, and biodiversity changes in the context of global change in the transition zone between the taiga and tundra in Arctic Yakutia.

Chapter 3 examines the vulnerability context of fishing communities of Arctic Yakutia in the face of environmental change and political transformations.

Chapter 4 considers the cryosphere change and the tension it creates in the political, social and territorial relationships that frame the Polar Regions.

Finally, **Chapter 5** summarizes and discusses the main findings of the thesis and provides concluding remarks and an outlook on possible future research directions.

2 "There are too many swans - but they are sacred": indigenous knowledge of biodiversity change in Arctic Yakutia

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Stanislav Ksenofontov, Norman Backhaus and Gabriela Schaepman-Strub conceived the study. Stanislav Ksenofontov prepared the interview and survey questions, conducted the field work and wrote the draft of the paper. Gabriela Schaepman-Strub and Norman Backhaus co-designed the questionnaire and interview guidelines, discussed the data analysis and edited the paper.

Abstract

Global change drivers such as climate change, new species, land use, and overexploitation have altered biodiversity in the Arctic. Biodiversity change has implications for local indigenous people since they depend on biodiversity for their traditional activities. Remote Arctic areas lack scientific records of biodiversity change and thereby it is vital to incorporate indigenous knowledge into scientific research in order to help fill in these information gaps. This study assesses indigenous knowledge of biodiversity changes caused by global change drivers in Arctic Yakutia in Northeastern Siberia, Russia. The results of the study demonstrate that global change has affected biodiversity at the study sites: new species have expanded ranges to the north, and the numbers of native species and phenology of plants have changed. Indigenous knowledge relates these biodiversity changes to different global change drivers, assumes that the changes are both naturally and anthropogenically driven, and reflects resulting alterations in species interactions in the forest tundra and tundra ecosystems.

2.1 Introduction

Global change is affecting biodiversity around the world. Many terrestrial, freshwater and marine species have altered their habitats, seasonal activities, migration routes, abundance and species interaction as a result of climate change (IPCC, 2014). Global change alters Arctic biodiversity too: boreal species expand their distribution northward and ecosystems change as a response to habitat warming and soil drying caused by earlier snow melt. As a consequence, southern species compete with Arctic species, which results in altered abundance and distribution, eventually leading to extinction. Decreased annual sea ice cover has affected marine species negatively including polar bears and walruses (CAFF, 2013). Arctic biodiversity is crucial for local indigenous communities since they depend on natural resources as food sources, for cash income and for social cohesion. Therefore, biodiversity change has significant implications for local people.

In 2013, the Arctic Council published an assessment of the status and trends in Arctic biodiversity (CAFF, 2013). However, this report contains very limited information about the biodiversity of Arctic Yakutia in Northeastern Siberia, Russia. Reasons might range from observational gaps due to scarce monitoring activities in this remote area (especially after the breakdown of the Soviet Union), to language barriers (much information is only available in Russian) and to hindrances in accessing unpublished resources. Indigenous knowledge can help to fill spatial and temporal gaps in scientific records. Therefore, it is important to 'incorporate traditional and local knowledge and to engage northern and indigenous communities in setting priorities, co-designing and co-producing research, and to disseminate this knowledge by ensuring access to research data and results' (ICARP, 2016).

This paper assesses indigenous knowledge of local people about biodiversity changes in Arctic Yakutia – in the transition zone between taiga and tundra – in the context of global change. We aim to understand which changes local people perceive in their environment and how they relate global change drivers to perceived changes in biodiversity. Firstly, the paper describes main characteristics of the biological diversity of Arctic Yakutia and the utilization of biological resources by indigenous communities; secondly, it addresses perceptions of drivers of global change and biodiversity change in Arctic Yakutia; and finally, the paper discusses how local people relate perceived biodiversity change to global change drivers.

2.2 Biological diversity and indigenous peoples of Arctic Yakutia

2.2.1 Biodiversity in Arctic Yakutia

The Convention on Biological Diversity (CBD) defines biodiversity as 'the variability among all living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems' (CBD, 2006). In this paper, we discuss the aspects of species appearance and extinction and changes in abundance of local species. The focus of this paper is on species important for subsistence, economic and socio-cultural use by indigenous communities.

Due to the expansive territory of Arctic Yakutia and the diversity of environmental conditions, the species composition of the flora and fauna is diverse. Extensive parts of the region are occupied by the tundra and tundra forest zones. Tundra is 'a vegetated treeless plain' and the forest tundra is 'the high-latitude subarctic vegetation between the circumpolar boreal forest and the arctic tundra' (CAFF, 2013; Payette et al., 2001). The total area of the tundra (22%) compared to the tundra forest (62%) is relatively small in the territory of Arctic Yakutia. The vegetation cover of the tundra mainly consists of low-growing plants: mosses, lichens and spreading shrubs (Okhlopkov, 2009). The forest tundra is composed of spruce forests with birch trees and a grass and shrub layer that contains swampy tundra species. Haircap moss, sphagnum and lichenous spruce forests are widespread in the forest tundra as well (www.atlas-yakutia.ru, n.d.). The Arctic Yakutian fauna is represented by Arctic endemic species, including the Arctic fox, Siberian crane, polar bear, reindeer, lemming, snow owl and partridge. The Arctic is a nesting place for millions of migratory birds such as ducks, geese, shorebirds and joggers, which every summer arrive in the high latitudes to breed and raise their young. The Yakutian tundra accounts for 74 nesting bird species and 26 mammals, while the forest tundra is much richer with 42 recorded mammal species (Okhlopkov, 2009). The fishery stock of Arctic Yakutia includes the littoral sea of the Laptev and East Siberian Seas with a total length of 5,000 km, and 9,053 rivers with a total length of

28,001 km. The 145,508 lakes comprise a total area of 4,345,000 ha. The fish fauna has more than 50 species (Savvinov, 2017).

2.2.2 Indigenous peoples' use of biological resources

Indigenous communities of Arctic Yakutia have for centuries been dependent on local natural resources. They have profited from biodiversity in hunting, fishing, gathering and reindeer herding for subsistence, economy, social cohesion and cultural identity. These activities have changed in the modern age, for example, that snowmobiles and boats have replaced dogs and reindeer, and rifles have substituted traditional primitive weapons. Nevertheless, traditional practices are still the mainstay of the indigenous communities' livelihoods. There are several reasons for this dependence (Nuttall et al., 2005) based on health, economic, and cultural measures. First, nutrient-rich Arctic food is considered healthier than imported food and is invaluable for indigenous people's health. Imported food is predominantly of low quality as a result of long delivery time in remote areas and delays associated with the weather. Imported food is expensive and beyond many local indigenous communities' means. Transportation costs of imported food are high due to long distances, accessibility by air transport only during summer time and small populations in the Arctic settlements. Second, traditional practices have a high cultural and social value. Hunting and fishing rituals, prey sharing, country food production and processing are crucial for local people to maintain their social, cultural and spiritual identities.

Sasaki (2015) classifies hunting into three categories: subsistence (self-supplying), commercial (market-oriented) and royal (performed for the training purposes of royal armies) (Sasaki, 2015). Indigenous communities of Arctic Yakutia practice hunting largely for subsistence and commerce. The main subsistence preys are wild reindeer, elk, hare and various birds such as ducks, geese and partridges. Prey for commercial purposes are fur animals like sable and Arctic fox. Over the last years, the number of wolves has greatly increased and threatened local economies and livelihoods. A governmental program has encouraged local people to hunt wolves as 'commercial' prey. Fishing is also an important traditional activity for local indigenous peoples as a subsistence, revenue and social fabric. Arctic Yakutian fisheries supply 73% of the whole catch in the Russian republic (Ksenofontov et al., 2017).

Reindeer herding is a key economic activity for most Arctic indigenous communities. A wild reindeer was domesticated by the ancestors of modern Evenki and Eveny people 2000-3000 years ago and used as a transport for hunting (Pomishin, 1990). It is a cornerstone of their culture, and through reindeer indigenous groups communicate as well as live in harmony with their harsh environment. Reindeer are useful in many ways: meat is an organic product rich in nutrients, reindeer milk is high in protein and lipid, antlers are used for production of

highly effective medicines, the hair is utilized for furniture production, the skin is employed for tailoring, making shoes, construction of yurts and reindeer itself is a good transportation 'vehicle' (Rogozhin and Rogozhin, 2010). Yakutia is one of the regions in Russia with the largest numbers of reindeers. Today, the number of domesticated reindeer is 179'192 heads as of June 2016 (arktika.sakha.gov.ru, n.d.). Within Yakutia, most of the herds are kept in the Arctic region.

Even though gathering is not as prevalent as hunting or fishing due to the 'limited availability of edible wild plants' (CAFF, 2013b), it still remains important for local indigenous peoples' subsistence. Gathering is mainly done by women and children. Usually gathering includes edible berries, mushrooms and a range of medicinal plants. Berries may be used in different ways: eaten raw, dried, boiled to make juices and canned. Mushrooms may be fried, dried or canned. Lack of pharmacological support, remoteness of settlements as well as high transportation fees require local people to rely on collecting medicinal herbs (Fedorov et al., 2015).

2.3 Global change drivers and Arctic biodiversity

Biodiversity is affected by both direct and indirect drivers of global change. Direct drivers of global change are affecting biodiversity explicitly: land use change, overexploitation, invasive species, pollution and climate change. Indirect drivers affect ecosystems altering direct drivers: population change, economic activity change, sociopolitical change, cultural change and technological change (Millenium Ecosystem Assessment, 2005). In this chapter, we focus on three critical drivers directly affecting biodiversity in Arctic Yakutia: climate change, land use and technology adaptation, and overexploitation.

2.3.1 Climate change

Climate warming is happening twice to three times as fast in the Arctic compared to the global mean. This phenomenon is known as Arctic amplification (Cohen et al., 2014; IPCC, 2014). Climate warming is already affecting tundra ecosystems across the Arctic, causing coastal greening (Bhatt et al., 2010), shrubification (Tape et al., 2006) and an increase of animal species (CAFF, 2013).

Also in the Yakutian Arctic, changes in the habitat of animal species have been reported that might be related to climate change. Over the last 40 years, the number of Siberian white cranes has significantly decreased due to tundra becoming water-logged. The Siberian white cranes are being outcompeted by the northward expansion of the Sandhill crane in the Arctic region of Allaikha (Bysykatova, 2013; Okhlopkov et al., 2013). Aerial

surveys and ground field studies in the 1960-80s did not detect Sandhill cranes in the lower Indigirka. The first breeding in that area was detected in 1998 along the Sundrun river. Today, the Sandhill crane is expanding its habitat to the western, northern and southern regions of Northeast Siberia (Bysykatova, 2013).

Wild reindeer respond to climate warming by migrating away from warmer to colder places, thus wild reindeer populations of Arctic Yakutia (Lena-Olenek, Yana-Indigirka, Sundrun) have been constantly changing their migratory routes depending on warming or cooling (Safronov, 2016). Interestingly, the effect of climate change on elk is rather different compared to the reindeer: elk increase their range and abundance with increasing temperature. Thus, the elk has expanded its distribution range northward to the tundra zone of 71° N while still being present in the warmer places (Safronov, 2016). According to hunters, the number of elk cows with twins increased in 2014 and 2015, which indicates that the fecundity rate of the elk population is rising. The elk has also increased in abundance: from 42,000 in 2001-2002 (Popov, 2002) to 70,000 in 2014 (MOP, 2015). This increase in elk population demonstrates that climate change has positively affected this species.

Habitat shifts of taiga mammals to the north were observed in Yakutia over the last decades. The brown bear is now inhabiting the lower reaches of the Indigirka and Kolyma rivers, where it threatens indigenous peoples by attacking domesticated reindeer and enters villages and fishing grounds (Okhlopkov et al., 2013). Thereby, it causes harm to the local subsistence economy and people's health. Sables, which used to be taiga mammals not long ago, are now typical in the tundra. Their numbers are gradually increasing year by year. Their population doubled in the Republic of Yakutia from 112,500 in 2005 (Stepanova et al., 2012), to 220,000 in 2015 (MOP, 2015). This population increase may displace endemic species such as the Arctic fox because sables are competing for the same prey. The distribution of infectious agents such as tick-borne encephalitis, Lyme borreliosis, tularemia and others is also expanding to the northeast with the movement of invasive host animals (Solomonov et al., 2012). These infections also pose a direct threat to local people's health.

2.3.2 Land use and technology adaptation

The main traditional forms of land use in the Arctic are reindeer herding, hunting, fishing and gathering. These land use activities in certain areas compete with the industrial exploration of mineral resource deposits. Changes in indigenous and industrial land use practices have, to some extent, altered biodiversity in the Arctic. Traditional land use usually presents sustainable exploitation of natural resources since indigenous communities are highly interconnected with their environment (Maynard et al., 2011). On the contrary, industrialization causes more disruption on biodiversity as a result of all-terrain vehicle (ATV) use, petrochemical contamination, infrastructure development, and modifications of

topography and hydrology (Kumpula et al., 2011). For example, in the Arctic Yakutian region of Olenyok, reindeer pastures have been affected by environmental stress on the soil from diamond mining, which resulted in the decline of reindeer herding (Takakura, 2012). However, our study sites do not contain mining sites and thereby experience industrialization effects only from development processes and adaptation of technology such as shipping, ATV and motor boat use.

2.3.3 Overexploitation

Changes in biodiversity may be triggered not only by environmental and climate change, but also by direct human harvesting activities. Commercial overexploitation of natural resources has been a significant threat to Arctic ecosystems and societies over centuries. There are historical examples of massive commercial hunting of eastern Arctic bowhead whales between 1600 and 1700, as well as blue, fin and humpback whales between the mid 1800s and 1920ies (Nuttal, 2005). Fish numbers have significantly decreased due to overfishing during the first half of the 20th century. As a comparison, in the basins of four major Arctic Yakutian rivers (Indigirka, Kolyma, Lena and Yana) 16,480 tons of fish were caught in 1943 whereas in 2015 this number was greatly reduced due to commercial overfishing as well as industrial development: 12 times less for the sturgeon, 5 times for the Siberian white salmon and 10 times for the muksun (Tyaptirgyanov, 2016). Decline of wild reindeer populations in Arctic Yakutia, especially of the Yana-Indigirka population has occurred due to unsustainable hunting, which almost resulted in the extinction of the entire population. In the 1980s, the number of the reindeer was 130,000, whereas in 2012 that number reduced to 1,500-2,000 (Safronov, 2005; Savvinov, 2017). While Safronov (2016) described the changes of reindeer migratory routes as a reaction to warming and cooling, Solomonov (2013) postulates that wild reindeer numbers have degraded as a result of anthropogenic pressure, one of which is delichenization (decline of lichen cover). The reason of this process is an overgrazing by domestic reindeer in the areas of wild reindeers' migration routes and stopovers (Solomonov, 2013). Hunting pressure in spring is considered a main reason of the dramatic decline of the lesser white-fronted goose and brent goose, migrating birds of the Arctic (Syroechkovski et al., 1998; Morozov, 2006). Nowadays, hunting of these birds is prohibited by the Red Book of Russia (Red Book of Russia, 2000). Various conservation programs at the global and local scale restrict overharvesting; however, related restrictions and regulations might not be accepted by local people who rely on those natural resources (Ksenofontov et al., 2017).

2.4 Methods

2.4.1 The concept of indigenous knowledge

Global assessments, such as the one performed by the International Panel on Climate Change (IPCC), largely rely upon peer-reviewed scientific research that often excludes indigenous knowledge, which is considered as less valid since it is not based on scientific principles (Alexander et al., 2011). However, scientific data may not be sufficient for global assessments, and some regions, especially remote ones, lack instrumental records. Moreover, establishment of monitoring networks may be expensive, but the involvement of indigenous knowledge may alleviate this problem (Lassuy and Lewis, 2013). Indigenous knowledge may serve as an additional source of information which can provide a human perspective to scientific data (Alexander et al., 2011).

Over the last years, indigenous knowledge (IK) received recognition as a useful source of Arctic environmental change (Huntington, 2011). Indigenous cultures have an extensive knowledge base about their ecosystems, which they transfer through communication from one generation to the next. This knowledge base is known as traditional ecological knowledge (TEK) (sometimes also referred to simply as traditional knowledge), which is 'a cumulative body of knowledge, practice and values acquired through experience and observations on the land or from spiritual teachings and handed down from generation to generation' (Pearce et al., 2015). TEK is transmitted orally and through demonstration, songs, stories, proverbs, and dance (Alessa et al., 2008). Employing the term 'traditional' may make this knowledge seem static, archaic or nonadaptive, although the knowledge and observations of indigenous people of their environment are often advanced and modern (Usher, 2000). Therefore, we will use the term 'indigenous knowledge' (IK) and focus on the knowledge through statements of indigenous people that express perceptions and observations of their environment. The use of the IK concept in our study helps us to build an overview of global change drivers and biodiversity changes occurring in Arctic Yakutia from the local people's perspectives.

2.4.2 Study area

This research is based on two case study areas located in four communities of two Arctic Yakutian regions: Chokurdakh and Olenegorsk in the Allaikhovsky region and Tiksi and Kyusyur in the Bulunsky region. These communities are situated in the delta of two rivers: the Indigirka flowing into the East Siberian Sea and the Lena discharging into the Laptev Sea. The sites are different in various ways: ethnically, the first two settlements along the Indigirka are mainly populated by Eveny and northern Sakha, whereas the two latter villages along the Lena are predominantly inhabited by Evenki and northern Sakha. Second, the effects of global change on biodiversity may differ due to the degree of development: the Lena delta is more industrialized and changes might be more pronounced. Third, communities

differ from each other by the biome in which they are located: Chokurdakh and Tiksi are situated in the tundra, whereas Olenegorsk and Kyusyur are located in the forest tundra. Detailed information on the communities can be found in the paper by Ksenofontov et al., 2017.

2.4.3 Interviews and analysis of responses

This study is based on two methodological approaches: 34 qualitative in-depth interviews and 204 quantitative standardized questionnaires, which were carried out in four Arctic communities in 2014 and 2015 respectively. Interviews encompassed five different groups of stakeholders initially identified by the research team: local authorities, key informants (i.e.indigenous knowledge holders such as hunters, reindeer herders), young people, elderly people and state workers. Before starting the interviews, meetings with local authorities were held to gain a brief insight into the research site as well as to draw up a list of indigenous interviewees. Male and female inhabitants of local indigenous communities – Eveny, Evenki and Sakha – participated in the interviews. Interviews covered the following topics: traditional subsistence practices of local people, indigenous knowledge regarding biodiversity, observed climatic and environmental changes in the region and their impacts on biodiversity.

The quantitative part of the research is based on the face-to-face survey and addressed questions about the main traditional activities (hunting, gathering, fishing and reindeer herding) as well as perceived environmental changes in biodiversity. Participants of the survey were from different ethnic backgrounds from indigenous and non-indigenous groups (Russians, Ukrainians) and different age groups. To assess respondents' agreements with statements on the questionnaire, we used a combination of methods including the Likert scale (with 5 levels ranging from 1 = strong agreement to 5 = strong disagreement), polar (yes/no) and open questions. In addition, the study comprised expert interviews, participant observations, collection of appropriate literature and documents, attendance of various local events, as well as review of official reports on environmental health in the region. The language of the interviews and survey was Sakha or Russian in accordance with respondents' command and preference in language. Interviews were recorded and then transcribed and analyzed using the MAXQDA software. SPSS was used to analyze quantitative data.

2.5 Results

Indigenous knowledge of local people in Arctic Yakutia associated with global change is quite strong due to their close relations with and dependence on their surrounding environment. In this section, we present this knowledge and divided it into several

subsections: 1) IK of global change drivers; 2) IK of biodiversity changes; and 3) IK of interrelations of global change drivers and their effect on biodiversity.

2.5.1 Indigenous knowledge of global change drivers

Global change has affected Arctic Yakutia. Local people observe climatic changes over recent decades. Land use and technology adaptation are also considered to have impacted Arctic Yakutian biodiversity. Biodiversity has undergone changes due to overexploitation as well.

Climate change

Indigenous knowledge of the interviewees regarding climate change in the region varies, but overall indigenous people agreed that the winter temperatures are rising and summer temperatures are decreasing. In addition, the weather tends to be more unstable:

'It is not so cold in recent years. Because we are children of nature and we know that. It is not going down below -40 to -45°C. Perhaps, it stays cold for a couple of days, but then it is warm again. I would say it gets warm' (M, 61).

'It has been 30 years since I came here. It used to be very hot on the first of June back then as if it was midsummer, but now (early July) it is cold. Summer has just started. It is getting colder year by year.' (F, 70).

'It is cold in the morning, then it gets warm, but in the evening it becomes cloudy' (F, 57).

Respondents were concerned about the high level of precipitation in recent years, it is both raining and snowing quite often:

'It is raining too much recently. It is snowing too much as well. I would say it is snowing in summer too. There is no snow only for one month in July. In August it starts to snow. It was not like this before' (M, 66).

During our first data collection in 2014, the water level in Olenegorsk and Kyusyur was considerably high. As a result, many fishers were deprived of their catch since the fish went deeper to the river bottom at higher water levels. However, in some years the water level is contrarily low, which also affects fishing and hunting practices of local people. For example, low water level may result in waterfowls scarcity.

Many respondents mentioned early river ice melt and late freezes as critical climate change effects in the region over the last decades. These changes have a significant impact on the traditional activities of local people. For example, late freezes can hinder hunting and fishing, since regulations limit these practices to specific times of the year. At times, the freeze in autumn is unstable and negatively affects coastal grounds. Some interviewees stated

that the river ice breakup sometimes brings disturbances to coasts that result in degradation of these shores.

A range of interviewees believes that climate change has a cyclic nature. A respondent recalls:

'Changes that occurred in the 1970s and 2000s are similar. It was so hot the entire summer, it was +30° C. The same hot summer occurred 2-3 years ago. They say the climate is changing, but I think it is not, changes of the past years happen again' (F, 57).

Land use and technology adaptation

Even though reindeer herding has significantly declined, it is nevertheless one of the main land use activities at the study sites. A respondent from Kyusyur recalls:

'We used to have 13,000 head in the 1990s, but today only 3,000 are left' (M, 50-60).

Kyusyur citizens are experiencing hard times. The township-forming company for traditional fishing and reindeer herding 'Bulunskoe' has been at the brink of bankruptcy for two years, and therefore is being operated by external management from Yakutsk. The new management is planning to divide the enterprise into two stock companies - one for fishing and another one for reindeer herding. Local people fear this will destroy reindeer herding as a traditional activity, since it has been continuing through the company thanks to profits from fishing. Olenegorsk used to be a highly profitable state farm (also called a 'millionaire" *sovkhoz* by the locals) during Soviet times when herders kept thousands of heads. After the Soviet regime dismantled, these communities lost state support and therefore the Soviet state farm collapsed. Nowadays, there are many times fewer reindeer:

'We had about 25,000 reindeer, today maybe 5,000 or 3,000 are left' (M, 61).

Fishing activities continue to be strongly regulated by the government, potentially impacting caught fish abundance. Thus, political drivers might also have a significant impact on biodiversity in this region.

Local people are concerned about excessive technological development in recent years. The use of heavy equipment and vehicles significantly disturbs the environment and wildlife. Technological development, in the villagers' opinion, is one of the probable causes why wild reindeer has shifted its habitat and moved further. A respondent from Olenegorsk recalled:

'Migration [of wild reindeer] has changed. Perhaps, it is due to a technological development. 10 years ago, they were migrating along this bank, wild reindeer used to pass by near Olenegorsk. Now there is no wild reindeer up to Deputatsk, Yana river. It has gone to the east, close to the Lower Kolyma region and does not come to the west – to the Indigirka river' (M, 57).

Local people have changed their berry gathering habit to employ so-called combined harvesters (small devices for picking up berries). Locals believe these devices eradicate plants resulting in damage and die out:

'20 years ago berries used to grow very well. Nowadays, many people pick up berries with combined harvesters, hence berries are not growing in those places anymore' (F, 55).

Moreover, plants are reported to be destroyed by the abundance of ATVs and other vehicles.

'I think all these disturbances occur due to plenty of vehicles, plenty of ATVs. They destroy all plants. Tractors go back and forth all the time' (F, 35)

Overexploitation

Technological developments have enabled local fishers and hunters to change their harvesting habits. According to interviewees, this has lead to an overexploitation of the resources:

'I think there are so many snowmobiles, and most likely due to this reason, the nature has many losses and damages. This has dramatically affected the environment. Now people can catch wild reindeer anywhere. Those who have a good vehicle don't leave anything behind.' (M, 53)

Most of the respondents claim that they possess environmental ethics and never overharvest natural resources. Overexploitation occurs mainly due to commercial activities of big companies. As one of the interviewees recalls:

'We have been fishing and hunting for a long time. And we never harvest more than we need. The fish factory used to catch thousand tons of fish before.' (M, 61)

2.5.2 Indigenous knowledge of biodiversity change

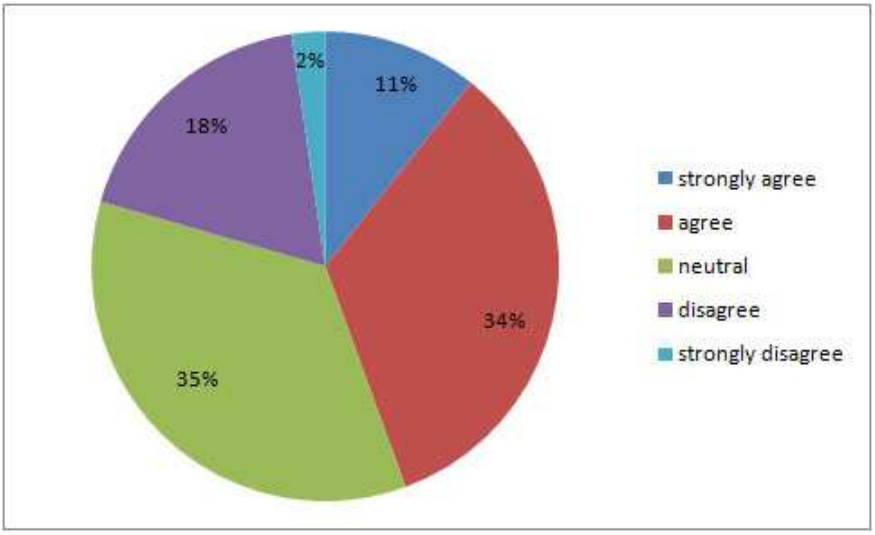
Local people agreed that new species have appeared in the forest tundra and tundra, but did not report or agree on tundra species extinctions. They noted changes in abundance of local species, such as an increase of swans or a decrease of ducks and geese. Further, they strongly agreed that migratory routes have changed over time.

New species and species extinctions

A crucial consequence of climate warming is new species appearing in the tundra ecosystems, through northward expansion of boreal species distributions (CAFF, 2013). In the quantitative surveys, 45% of the respondents agreed or strongly agreed with the statement 'There are new species in the region', whereas 20% disagreed or strongly disagreed and

another 35% were neutral in their response (the mean of 2.66 thus is below the middle weight of 3 and therefore closer to agreement; see Fig.3).

Figure 3: Level of agreement with the statement 'There are new species in the region", as expressed by respondents during the quantitative interviews.



Although the quantitative data is not very convincing, most of the respondents of the qualitative interviews reported new species in the tundra that are common for the taiga biome (Table 1), for example wolves, bears and sable.

Table 1: New species and changes in abundance of original species in the forest tundra and the tundra along the Indigirka and Lena river

Change	Indigirka		Lena	
	Tundra	Forest tundra	Tundra	Forest tundra
New species	Animals: ant, grasshopper, lizard, muskrat, muskox, sable, unknown birds, crow, white seagull, mallard, unknown fish Plants: unknown flowers	Animals: lizard, squirrel, muskrat, muskox, bear, wolf, sable, red fox, unknown birds, crow, mallard, ducks, unknown fish Plants: unknown flowers, Capercaillie, Astragalus, Baikal	Animals: sable, muskrat, ant, swift, teal, swallow, rook, magpie, eagle, sparrow Plants: unknown plants	Animals: bear, sable, muskrat, wolf, crow, swallow

		skullcap, purple willow, dandelion, chamomile, blackberry, bellflower		
Increased abundance	Swan, crane	Swan, crane, small black geese, Arctic fox		Arctic fox, bushes, swan, trees
Decreased abundance	Reindeer, ducks, geese, partridge, pink seagull, gull	Reindeer, snowdrop, pink seagull, billfinch, scoter, wader, squirrel, grouse, fish, gull, elk, ducks, geese, omul, berries, mushrooms, partridge, stiff-tailed duck, polar owl	Bullfinch, pink seagull, reindeer, marmot, grouse	Lark, cuckoo, berries, ducks, geese, omul, wild rosemary, mosses, partridge

Over the last decades, the number of predators has significantly increased in the forest tundra.

'There are many wolves and bears. They even came into the village last autumn. It's bad that there are many predators, because it's dangerous for people.' (F, 59).

The sable was unobservable in the tundra and forest tundra until recent times, however nowadays it is abundant at the study sites:

'They say the sable has come to the tundra. If it was common in the taiga before, now one can find it even in the tundra. There are many of them here.' (M, 46).

People also observe new birds which were uncommon for the area and some respondents couldn't even recall their names except mallard, shoveler, lesser white fronted goose, small black geese:

'Some untypical birds have come. I haven't heard these beautiful sounds before.' (M, 51).

'They say in the 90ies, a bird from the Red Book, which is called lesser white fronted goose, can be seen now in the tundra, whereas we haven't seen it when we were kids.' (F, 38)

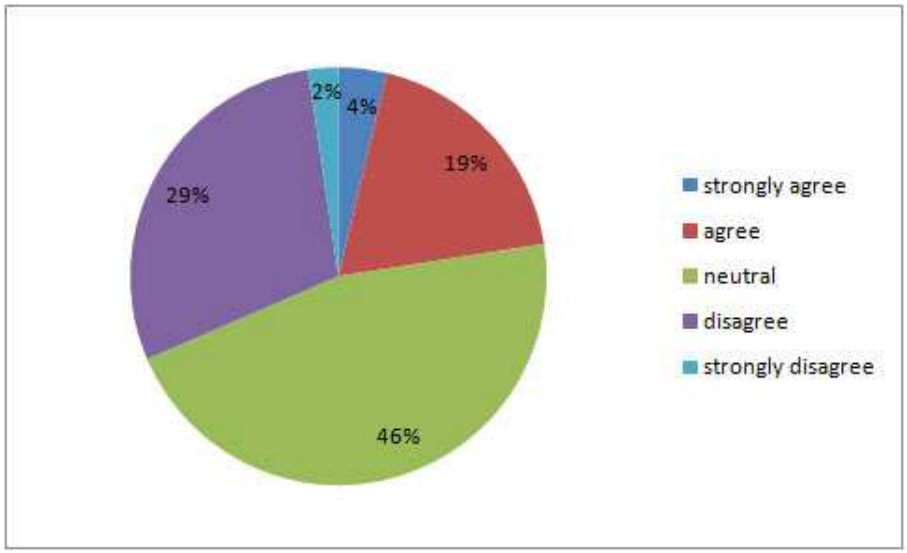
Some of the interviewees of both biomes stated that over the last decades, they observed unusual plants not seen before and did not even know their names.

'The number of plants is increasing. Of new plants. There are new flowers whose names I don't know.' (F, 59).

Some of these plants were typical of the boreal forest, such as dandelion, chamomile, bellflower, black currant and rose bay. Now they are growing in the tundra and forest tundra. Overall, abundance of boreal plants was reported to increase in the forest tundra.

The species might be extending their distribution as a result of global change, while original species might also be going extinct. However, responses of the quantitative questionnaires were neutral with respect to species disappearance. Most of the local people remained nonsupportive of the affirmation 'Some species have disappeared' with a mean of 3.06 (see Fig.4).

Figure 4: Level of agreement with the statement 'Some species have disappeared', as expressed by respondents during the quantitative interviews.



Changing abundance, growth, and phenology of local species

Another expected impact of global change drivers on biodiversity is a change in abundance and growth of local species. According to the respondents, the number of tundra swan is constantly increasing at the study sites:

'It seems the number of swans has increased. When you go to the other bank of the river, you might hear their cawk by the lake' (F, 63).

In the traditional belief of some indigenous communities, swans are spirit birds comparable with the gods. Killing them is considered as a sin. Even stepping on a feather is deemed to be sinful. However, some interviewees suppose that the abundance of swans is

harmful for a number of endemic species. For instance, swans destroy eggs and kill geese, ducks and Arctic foxes. The Siberian crane - another endemic bird species - is becoming more abundant in the area, especially in the protected zones such as 'Kytalyk' in the Allaikovsky region.

'There are many cranes. Cranes are always flying near the village and it seems they bring out nestlings.' (F, 47)

Hunters reported and face a decline in ducks and geese numbers, even though waterfowl breed in the Arctic during summer.

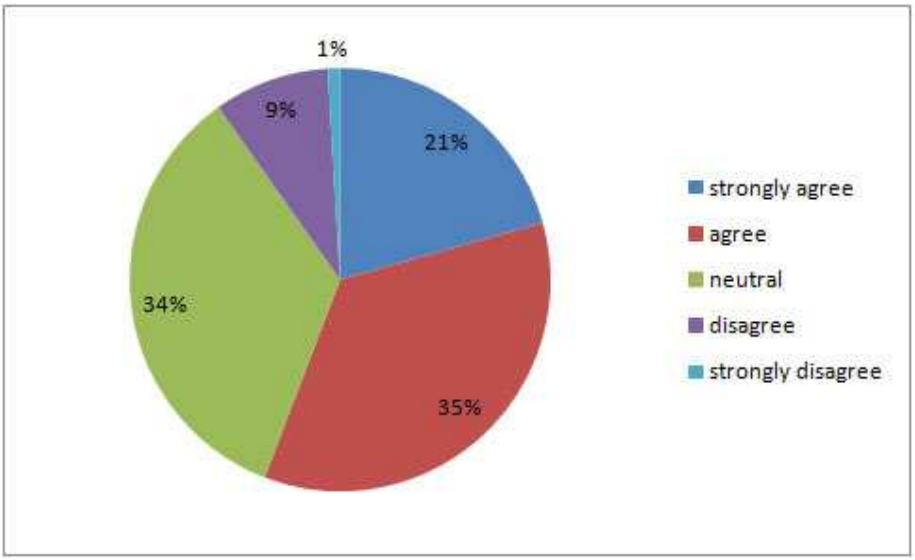
'The number of ducks along the Indigirka river has decreased a lot. For example, in autumn I and my brother in law harvested 11 ducks. But my friends from the Suntar region [in the south] sent me a message by whatsapp that they harvested 200 ducks within 2 or 3 nights. I don't believe them or it's such a luck.' (M, 51)

These birds are an important subsistence game, and their decrease is negatively affecting the diet of local indigenous communities. Other birds are also perceived to be in decline, Small birds have disappeared and it is difficult now to hear their songs:

'Around the 50s, 60s after the war, there were many birds that even didn't let us sleep. All sorts of birds, ducks, every puddle had birds. It was so noisy all around the tundra, birds' song, diver's twitter in the lakes. It is so calm in the tundra now... only a small amount of birds is there.' (M, 75)

Finally, people were interviewed about their perception of vegetation changes. According to 56% of the interviewees, vegetation cover and the quality of the pastures had changed (mean: 2.34; see Fig.5).

Figure 5: Level of agreement with the statement 'Vegetation cover and the quality of pastures have changed', as expressed by respondents during the quantitative interviews.



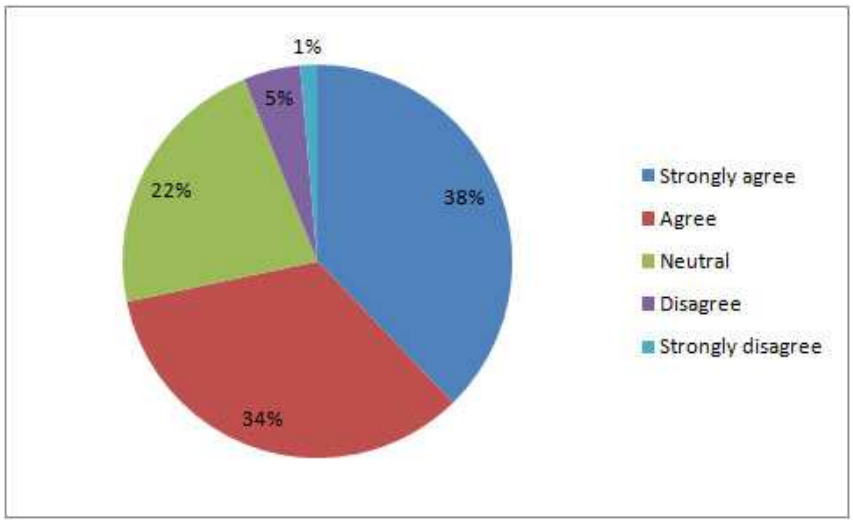
The statement that 'Vegetation cover and the quality of pastures have changed' does not indicate the increase or decrease of this change. The direction of change in vegetation can be evaluated based on the qualitative interviews. In the transition zone (Kyusyur and Olenegorsk) the forest is reported to be more lush than before. The trees have become taller and the grass longer.

As a respondent from Olenegorsk reported, one of the sacred plants, wild rosemary, was in decline in 2014, which may have an impact on cultural and spiritual well-being of local communities. Wild rosemary is usually used for creating smoky fires to clear space and drive away evil spirits. Plant phenology and fruiting have also undergone alterations. Many respondents reported the early arrival of spring, with the growing season of some plants starting earlier than before. In terms of fruiting, some plants demonstrate irregularity. For example in 2013 blueberry was scarce. The previous year it was abundant. People previously collected cloudberry and blueberry during two separate periods (cloudberry in July and blueberry in August). Nowadays it has merged into one phase - between the end of July and beginning of August. Due to sudden early snow fall, plants can die and people are not able to collect berries.

Changing migratory routes

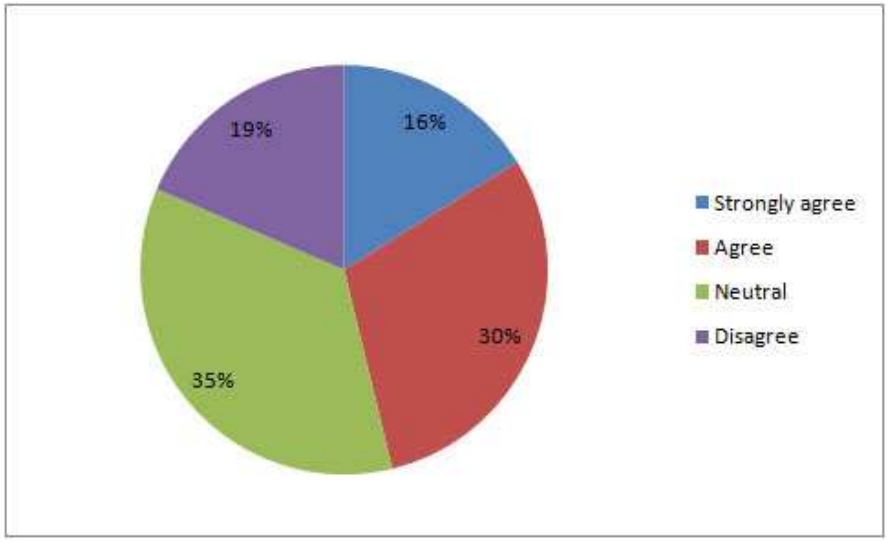
Most of the survey participants (72%) expressed their agreement or strong agreement with the notion that animals' migratory routes have change (mean: 1.97; Fig. 6).

Figure 6: Level of agreement with the statement 'Animals' migration routes have changed', as expressed by respondents during the quantitative interviews.



Regarding birds' migratory route change, 46% of the respondents concurred with the statement (mean of 2.57; Fig. 7).

Figure 7: Level of agreement with the statement 'Birds' migration routes have changed', as expressed by respondents during the quantitative interviews.

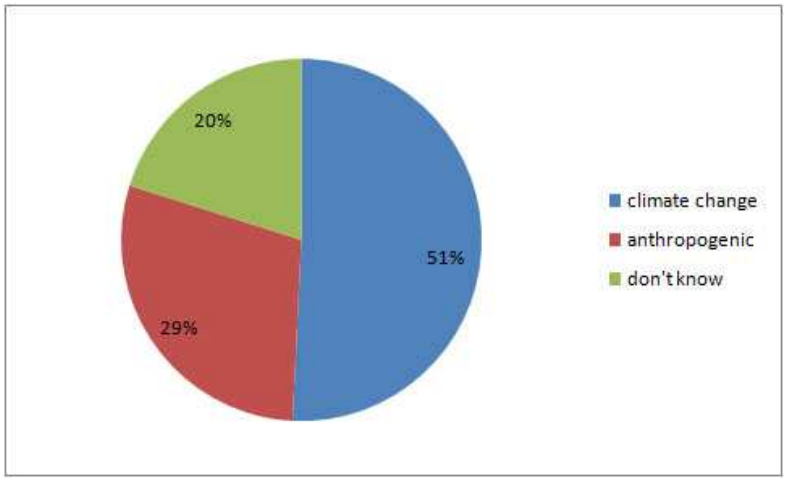


2.5.3 Indigenous knowledge of interrelations of global change drivers and their effect on biodiversity

Local people relate biodiversity changes to all three global change drivers – climate change and anthropogenic factors – specifically land use change and technological adaptation (e.g. motorboats, snowmobiles, utilization of combined harvesters) and related overexploitation. Furthermore, they mentioned impacts on species interactions.

The quantitative survey demonstrates that the majority of respondents (51%) relates the species number increase or decrease with the events associated with climate change. 29% of surveyed believe that species alterations are caused by anthropogenic factors (Fig.8).

Figure 8: Reasons for species increase or decrease



Expansion of new plants are believed to occur as a result of warming, because spring arrives earlier and warmer periods last longer. Willows are reported to grow where they never grew before, and they appear to become taller now:

'It is getting warmer every year. That's why new plants arrive. For example, this goat willow seemed to be shorter before, but now it is tall.' (F, 59).

Forests were reported to become more lush. Respondents attribute this to the warming and termination of deforestation. It has become warmer over the last years, producing more favorable growing conditions.

'Our trees are small. They seem to grow. In some places it became lush, there are many bushes.' (M, 68).

Bears and wolves shifted their distribution range northwards. Many of the respondents attribute this phenomenon to forest fires in the southern regions, which force predators to escape northward. During the fieldwork in 2014, an author witnessed such a dense continuous smoke in the village of Kyusyur that even the sun was invisible. Forest fires also disrupt reindeer pastures. A large fire occurred near Kyusyur 3-4 years ago, which destroyed a vast area of the grazing ground.

One of the interviewees pointed out a strong interrelation between climatic changes and fluctuations in species abundance:

'You can see changes through fish. Why have fish gone? Perhaps due to a high water [level], or riverbed change, or warming. Everything is related.' (M, 47).

Scarcity of birds is attributed to the low level of water. Some locals believe ducks and geese avoid the region due to a lack of water, unlike in southern Yakutia:

'I heard there are many ducks in southern Yakutia because spring is early and lots of water' (M, 61.).

Some respondents relate a decline in berries to the small amount of snow in winter. If it snows heavily, then berries will be abundant.

One expert respondent from Tiksi counters concerns about anthropogenic impact on biodiversity by claiming there are other reasons for these changes. He explains that southern species naturally expand to the tundra due to a flow of warm air together with an ice drift along the Lena river. In addition, he believes it is not a massive and permanent expansion, because it would be difficult for alien species to adapt to the harsh Arctic environment.

Some respondents attribute changes in biodiversity to anthropogenic pressures. One of the most critical effects on biodiversity is considered to be human waste and garbage. Some houses in Chokurdakh are not equipped with suitable septic tanks, which results in river contamination. Olenegorsk is strewn with garbage, and the local administration cannot scavenge it to the disposal field since it does not have any vehicles. The entire Yakutian

Arctic (and Russian Arctic as well) is littered with scrap metal left after USSR military and industrial activity. The situation is may be changing for the better, though. In 2015, the government issued a decree to clean up the Arctic. It reported that 162 hectares of the Arctic territory was cleaned by the end of 2016 (www.tass.ru, n.d.).

Interview participants ascribe biodiversity disturbances to the abundance of vehicles in recent decades. Snowmobiles, motorboats, ATVs, tractors and cars are massively employed by the local people for hunting, fishing and daily life that they destroy the soils and plants. In addition, people with vehicles can reach faraway lands and catch a prey, sometimes in a very unsustainable manner:

'Rapid technological development for hunting is under way. There are all kinds of motorboats, and they can go everywhere. They are like arrows. And they disturb the entire tundra. After the development of motor boats we have no reindeer, no birds and even fish' (M, 75).
'There are very few reindeer left, because of too many snowmobiles' (M, 61).

However, respondents also mentioned a release of anthropogenic pressure on some species and ecosystems. For examples, people reported that some animal populations have increased as a result of less human pressure:

'The amount of Arctic fox has also significantly increased over the last decades…due to the fact that it is not well hunted because the fur trade has declined' says a former tractor driver (M, 66).

Also, in addition to climate change promoting forest densification, respondents mentioned that densification has also reasons associated with technological adaptation. In earlier times, local people used to cut trees for heating, but nowadays all houses are supplied by the central oil heating system:

'There are so many trees everywhere. And they are so tall. It was a treeless place 30 years ago. Perhaps it is because of tree cutting. Back in the days trees always used to be cut for firewood' (F, 55).

Indigenous knowledge shows awareness of biodiversity changes through species interactions within the ecosystem, as was mentioned in the swan example. One of the respondents attributes gull numbers decrease with fish scarcity. If the fish goes down to the bottom, gulls cannot catch the fish, and, therefore, translocate to a better place.

Furthermore, when the reindeer migrated near villages, plants were trampled down. Now the vegetation cover has become revived since the migration route shifted.

2.6 Discussion

This study reports and synthesizes indigenous knowledge of local people on global change drivers and biodiversity changes in Arctic Yakutia. Results show that people closely observe their environment and are concerned about the effects of global change on their environment's biodiversity and its effect on subsistence, health and safety, as well as spiritual well-being. They, however, also report a few positive effects.

Warmer winters may negatively affect food access of reindeer. During warmer winters, rain-frost cycles cause the formation of ice layers in the snow, which makes it difficult for reindeer to feed (Maynard et al., 2011). Heavy snowfall may also form ice layers and block access to food, since reindeer feed by excavating snow to access the grass underneath. In the case of high snow depth, it is difficult for the reindeer to dig out food. For example, in the Arctic Yakutian region of Lower Kolyma, reindeer starved as a result of an abundant snowfall in 2016 (Regnum, n.d.). In summer 2017, Arctic rivers, including Indigirka, flooded many settlements and facilities such as airports, roads and bridges. The reason for dramatic flooding, experts say, was the large amount of snow, which in some places had been almost sixfold as compared to the long-term average (www.gazetayakutia.ru, 2017). Early ice breaks may further create challenges for reindeer migration, especially for the fawns, which can be swept away by streams in their attempt to cross open waters (Klein et al., 2005). Hence, global warming affects Arctic reindeer herders' livelihoods in predominantly negative ways, especially since the deer are not only an economic resource but also culturally important.

The expansion of new species to the tundra may have both positive and negative implications for local indigenous communities. Among the positive consequences are the economic benefits that new species bring. The abundance of sable in the Yakutian tundra has spurred commercial trapping and hunting of this species, making it an additional income source for indigenous peoples. The sable accounted for 92% of the total purchase made by procurement companies of commercial fur in Arctic Yakutia in 2013 (Savvinov, 2017).

The reduction of the hunting pressure on the endemic Arctic species and the observed increase in their abundance may therefore rather be a result of economic shifts and political reasons and only indirectly linked to climate change. Before 1990, the Arctic fox was one of the major commercial species in Yakutia. Monetarily, Arctic fox fur comprised 10% of the total production of all furs in the Republic (Savvinov, 2017). After the USSR collapse, Arctic fox hunting was stopped due to low selling prices for its fur, increasing prices of fuel and lubricants as well as the complete cessation of state supplies for hunters (Solovyev, 2012). Sable hunting has also replaced squirrel hunting in the bordering territories between taiga and tundra in the Arctic Yakutian region of Lower Kolyma (Mustonen, 2011).

As it was stated above, the distribution of the Siberian crane in Arctic Yakutia has shifted as a result of the northward expansion of the Sandhill crane (Bysykatova, 2013). Nevertheless, local people observed abundant Siberian crane in the nature reserve 'Kytalyk' near Chokurdakh. This may indicate that indigenous knowledge of some respondents regarding species has either diminished or differs from the scientific records.

The immigration of taiga predators to the Arctic (tundra) negatively affects not only endemic mammals and birds, but also people. In addition to concerns about people's safety, economies are negatively affected by the advent of these predators: wolves attack domesticated reindeer and bears enter fishing grounds and destroy fishing nets. Therefore, authorities have included these predators in the hunting list and encourage local people to hunt them by handing out rewards. Although data is not available for the impacts of predators on reindeer, in Scandinavia, these predators constitute a serious danger for reindeer husbandry (CAFF, 2013). For example, in Finland bears killed 656 and wolves 558 reindeer in 2014 (www.paliskunnat.fi, n.d.). Reindeer herders also face personal threats from these large predators.

The expansion of new plants into the study areas is positive from the local people's perspective. New berries, flowers and plants arouse interest of the northerners, especially in the context of poor vegetation diversity of the region. Most of these new plants are observed in the transition zone between taiga and tundra (i.e near Olenegorsk). These observations are aligning well with an earlier study reporting that the borderline of tree and shrub vegetation in the lower reaches of the Anabar, Olenyok, Lena, Yana and Indigirka rivers are shifting to the north (Tishkov and Krenke-jr., 2015). A range of new plants is reported to have health-promoting effects. For example, a boreal Astragalus species that strengthens the heart is now found in the tundra forest around Olenegorsk. Another boreal herb, the Baikal skullcap, contains flavonoids, which are anticancer agents. For local people, berries are a source of vitamins. The appearance of new berries enriches their diets. The vitamin C-rich black currant, a taiga berry, can now be picked in the tundra forest near Olenegorsk.

It is worth noting that the rapid expansion of new plants may be human-induced. Often seeds are transported by trucks and cars, which is why invasive species are often discovered first at road shoulders before they spread elsewhere. Also, interviewees assumed that new plant species might have arrived with gravel brought for the construction works. Disturbances by vehicles may remain for decades, and the revival of the tundra vegetation is normally slow as a result of modified thermal and hydrological conditions as well as low fecundity of many Arctic species (Kumpula et al., 2011). Thereby, local people observed regular variabilities in the plant species distribution, especially berries.

The number of waterfowl decline may be connected to unsustainably over hunting during the birds' migration to and from the Arctic and in winter, predominantly in China

(Syroechkovski et al., 1998). Their breeding success may be affected by the population changes in lemmings and their predators, such as Arctic fox. The latter changes its prey to shorebirds and waterfowl eggs when lemming populations decrease due to climate change (CAFF, 2013). In addition, Arctic foxes eat eggs in times of low rainfall when parent birds need to leave their nest to drink or feed. Hence, water availability near a nest during high rainfall may increase the reproduction of waterfowls (Lecomte et al., 2009). The abundance of tundra swans may also have negative implications for the distribution of other species because swans are carnivorous birds and feed upon other birds and mammals. Lastly, a decrease of songbirds may have an adverse effect on local people's spiritual well-being. While it seems that hunting practices outside the Arctic have the biggest impact on the number of waterfowl, decreasing rainfall in combination with an increase of Arctic foxes (and a decrease in lemmings) further negatively impacts nesting birds. People not only miss bird-songs (and thus perceive this as a diminishment of a cultural ecosystem service) their loss is also felt as an indicator of profoundly negative changes.

The shift of wild reindeer migration routes causes hunting costs to increase, especially when snowmobiles are used because they require fuel. In addition, hunters also have to stay longer on their trips, they need more food and miss out other activities. This may be confirmed by the past climate periodicity associated with warming or cooling when the wild reindeer shifted the migration route. For example, the Sundrun population of wild reindeer in the mid 1990s moved eastward to the Kolyma river, where it had not been seen for over 50 years since the last warming (Safronov, 2016).

Besides global warming, other global change drivers have significantly affected reindeer herding in the research sites. We can highlight several drivers of this effect. First of all, the most important factor to have an impact on the local people's herding practices has a socio-political rationale. The Soviet regime collapse in 1991 and the transition to a market economy caused a significant decrease of reindeer herds in the entire country, including Yakutia. Since then, the collapse reindeer herding has dramatically declined and stopped being profitable. Many herders shifted to hunting and fishing as these traditional practices were less expensive for bringing income. As a comparison, the herds in Yakutia reached up to 380,000 heads between 1965 and 1991, and reindeer herding at that time was a tremendously profitable industry (Klokov, 2016). Today, this number is less than half of that. Moreover, many herders have to kill their own reindeer to sustain themselves due to low wages or delayed salary instead of selling them for a profit. Secondly, husbandries are affected by increases in wild reindeer. When the wild reindeer pass by the herds, the domesticated reindeer follow them and thereby it is difficult for herders to find them again. Finally, the reindeer herding decline may also be impacted by the migration of young people to urban settlements and a lack of interest in continuing their ancestors' traditional activity in the face of these difficulties.

2.7 Conclusion

Global change affects biodiversity in Arctic Yakutia in different ways. In some areas, land use and overexploitation may have a stronger impact than global warming. In combination with sociopolitical changes (i.e.the collapse of the Soviet Union and increasing prices for commodities) it strongly impacts the livelihoods of Arctic people, both in negative ways (i.e.decreasing number of waterfowl or altered migratory routes of the reindeer) and positive ways (i.e.increasing number of berries and medicinal plants or warmer winters). Hence, subsistence practices, food security, well-being and safety of Arctic communities are strongly linked to the actions of the global community through migratory species and climate warming.

In addition to scientific observations, indigenous knowledge is invaluable regarding the detection of global change, its drivers and impacts. Both show that biodiversity is affected both positively and negatively. Warmer winters block food access of the reindeer, invasion of taiga predators inflicts damage to the local economy, and the expansion of sable creates economic possibilities for the local people. However, indigenous and scientific knowledge can differ, for example, in whether or not the Siberian crane population is increasing. The detection of such discrepancies can and should be the reason for closer (and cooperative) inspection.

As our study demonstrates, global change in Arctic Yakutia has both natural and anthropogenic reasons. Interviewees relate changes in biodiversity to technological development (abundance of vehicles as well as shipping), and natural processes (increasing precipitation). The narrative of the predatory, but sacred swan in the title of this article symbolizes the quandary indigenous people of the arctic find themselves in when trying to deal with global change.

3 "To fish or not to fish?": fishing communities of Arctic Yakutia in the face of environmental change and political transformations

This chapter is based on Ksenofontov, S., Backhaus, N. & Schaepman-Strub, G. (2017). “To fish or not to fish?”: fishing communities of Arctic Yakutia in the face of environmental change and political transformations and reprinted as published in the journal. *Polar Record*, 53(3), pp.289–303. DOI: https://doi.org/10.1017/S0032247417000134.

Stanislav Ksenofontov, Norman Backhaus and Gabriela Schaepman-Strub conceived the study. Stanislav Ksenofontov prepared the interview and survey questions, conducted the field work and wrote the draft of the paper. Gabriela Schaepman-Strub and Norman Backhaus co-designed the questionnaire and interview guidelines, discussed the data analysis and edited the paper. Norman Backhaus drew the figures (except the map).

The publication is listed as ‘editor’s pick’ on the website of the Polar Record journal.

Abstract

This paper assesses the vulnerability context of Arctic fishing communities. We hypothesize that climate change related trends – such as increasing temperature and altered seasonality– and shocks – such as the breakdown of the Soviet Union or new fishing regulations – increase Arctic local peoples' vulnerability and compromise the sustainability of their livelihoods. Research shows that over recent decades local people have observed environmental changes and a significant decrease in the number of fish caught. Fishing regulations introduced after the collapse of the USSR burdened fishers with quotas and temporal limitations which have hindered their fishing activities. While traditional adaptation of fishing techniques to seasonally changing conditions might increase their adaptation potential to future conditions under climate change, fishing regulations appear to limit this adaptation potential.

3.1 Introduction

Climate warming in the Arctic is more intense than in any other region of the planet (ACIA, 2005, AMAP, 2012). As a result northern terrestrial and aquatic ecosystems are experiencing profound changes, which impact the natural resources of local people (Callaghan and others, 2011). Local people of Arctic Yakutia in North-Eastern Siberia have for centuries been highly dependent on the natural resources which they have collected as fishers, hunters, gatherers and reindeer herders (Nuttall and others, 2005, Alekseeva, 2012).

Climate change is expected to have an impact on Arctic fish populations, and they are likely to face much larger changes than those in tropical regions (Ficke and others, 2007). Many Yakutian fish species tend to shift northwards as a response to climate change. Several species in the Lena river may migrate to the estuary, which is stocked mainly with whitefish and char. This results in elevated competition between local Arctic fish species and newcomers. As a consequence native species populations may become depleted by northwards migrating predators (Ficke and others, 2007). Increased temperatures may cause higher rates of bacterial diseases in aquatic ecosystems (Hefer and Pruginin, 1981, Wedemeyer, 1996). It is known that white fish in the lower courses of the Lena and Indigirka rivers have been infested by 12 types of parasites (Kokolova and others, 2012).

In addition to climate-induced changes in the abundance of natural fish resources, the livelihoods of Arctic local communities are affected by other factors such as the collapse of the Soviet Union, changing fishing and hunting regulations, depopulation, and the challenges of living in remote areas (West and Hovelsrud, 2010). Furthermore, high rates of unemployment (75-80%) have increased their dependence on natural resources (Lavrillier, 2013).

This paper therefore attempts to assess the vulnerability context (DFID, 2002; Carney, 2003) of these communities, both indigenous and non-indigenous. We hypothesize that trends such as climate change, shocks such as the breakdown of the Soviet Union or trends such as the introduction of new fishing regulations, increase Arctic peoples' vulnerability and compromise the sustainability of their livelihoods. Hence, the article aims to understand which above mentioned stressors impact on the livelihoods of local people and increase their vulnerability. Moreover, we attempt to find out whether and how adaptive strategies adopted by the Arctic communities are appropriate to cope with the pressures. The assumptions and hypotheses are tested using qualitative and quantitative interviews performed in two Arctic regions of the Republic of Sakha (Yakutia). The paper firstly describes impacts of climatic and environmental change on the Arctic communities in the Republic of Sakha (Yakutia), fish species, fishing practices as well as livelihoods as perceived by the local people. Secondly, it draws attention to the effects of political and institutional change on the livelihoods of local populations of Arctic Yakutia. Thirdly, the study assesses and discusses the social and economic impacts of changed fishing regulations and how they influence adaptation potential to future climate impacts.

3.2 Climate change, fish and political transformations

3.2.1 Impact of climate change in Arctic Yakutia

Investigations into the impacts of climate change on fish and subsistence fisheries have been conducted in Arctic regions (Nuttall and others, 2005; Reist and others, 2006; Prowse and others, 2006; AMAP, 2012; Moerlein and Carothers, 2012; Arctic report card, 2015; Hendriksen and Jørgensen, 2015). However, little is known about the situation regarding fish in the Yakutian Arctic.

Shadrin (2009) reported the difficulties faced by two fishing families when lakes in the village of Andryushkino in North Yakutia dried out. Thawing permafrost caused the lake to shrink and as a result these families were left without their traditional food (Shadrin, 2009b). Mustonen (2011) in his research in the northern Yakutian district of Lower Kolyma noted that many lakes also have shrunk, causing a reduction in fish numbers. As a result, fishing is no longer possible in these areas. The timing of freezing and the break-up of the ice have changed, so ice roads become dangerous to travel for hunting and herding during the traditional hunting season in spring and autumn. (Mustonen, 2011).

3.2.2 Fish: more than food

Fish is a crucial biotic resource for the Arctic local people. Fish is important not only as food, but also as a cash income source (Caulfield, 2000). Moreover, fish plays an important role in the social fabric of the local people. Fish species consumed and traded by local people

include Siberian white salmon (*Stenodus leucichthys nelma*), Siberian cisco (*Coregonus sardinella*), Arctic cisco (*Coregonus autumnalis*), *muksun* (*Coregonus muksun*) (Kirillov, 2002, Kirillov, 2007) and many others that seasonally migrate from marine to freshwater ecosystems (Nuttall and others, 2005). Fishery is the most important income producing industry of the region. Yakutian fishers are associated in *obshchinas* – "self-organized indigenous communities recognized under Russian Federal Law" (Mustonen, 2011: 3) – as small-scale fisheries to trade fish on markets in the capital city Yakutsk or to sell to bigger enterprises in Yakutsk. These *obshchinas* provide 73% of the whole catch of Yakutia; for most of the Arctic people fishing is the only source of subsistence and employment (Totonova and Sleptsov, 2014). Furthermore, the Russian legislation defines six other types of fishing practices (besides small-scale fisheries), two of which are employed by local Arctic people: indigenous communities practice traditional fishing for subsistence purposes; non-indigenous individuals are allowed to exercise amateur and sport fishing. In this paper we will focus our attention on small-scale fisheries (*obshchinas*) and traditional fishing. Fishers employ different fishing techniques, depending on the season and related conditions (Sirina, 2012, Tugolukov and others, 1997, Ziker, 2002):

- Ice-fishing with nets, where nets are put through holes after the ice freeze up in October.
- Winter fishing under the ice with a short rod that is lowered through a hole in the ice.
- Spring thin-ice fishing, where in April and May nets with small 25-millimeter cells are lowered through holes that are drilled into the ice. Compared to ice-fishing with nets, spring thin-ice fishing occurs in the upper drainage of a river on thin ice which forms during the winter under the pressure of snow.
- Open-water net fishing, where nets are used on the open water after the ice break up in early summer until the river freezes in late September. Only nets of a certain length (maximum 25 m), can be used for this type of fishing according to regulations.
- Seine (nevod) fishing, where a U-shaped dragnet (nevod) is used during the summer months.

With the example of Allaikhovsky region, we can demonstrate that fishing in the region is organized in two technological cycles:

1) landing, freezing, storing at the fishing grounds;
2) collection and transportation from the fishing grounds to the reception station, located in the capital of the region, Chokurdakh.

Landing occurs in the distance of 10 to 250 km downstream and upstream of the Indigirka river, 180 km from the region's capital, 140 km along Allaikha river and 480 km along the Elon river. Transportation to the reception center is not carried out timely in summer, because it is delivered by motor boats which is the most expensive part of the industry (Investment Passport, 2015). From the reception center fish is delivered to Yakutsk

either by airplane or trucks by winter ice road. This is tremendously expensive due to high transportation rates (55 rubles (ca. 1 US$) per kg) and lack of year-round road (Regnum, 2016a). As a result fish in Yakutsk markets is extremely expensive. There was only one fish processing plant in the region, built back in 2011 and which, for reasons undefined, did not even operate until it burned down in January 2017. However, over the last years the Yakutian government launched various programs to support Arctic fishers: it compensates 90% of expenses for refrigeration and freezing equipment as well as reimburses fishers' expenditures for fishing (Regnum, 2016b). In 2015 it allocated 65 million rubles for the modernization of the fisheries industry: fishing bases, modular fish primary processing plants, refrigerator containers have been purchased in the Arctic regions including our research sites(AGiP, 2015)

An important element of harvesting the natural resources of the local people is *nimat* – "distribution of equal shares of spoils of the hunt among the whole local community" (Forsyth, 1989: 76). According to this custom any spoil is subject to a compulsory equal distribution among all families of a campsite (i.e. a hunting or fishing party), including families of neighboring camps (Tugolukov and others, 1997). Anisimov (1936) describes *nimat*: "when a hunter kills an animal, he should announce this to a camp member. Then a body of hunters selects a person – receiver of *nimat* – normally the poorest family of the camp. This person then equally distributes the spoil among all families of the camp. *Nimat* can be applied not only to animals and birds, but also to fish" (Anisimov, 1936: 76-77). Offense against this custom would make *Buga* (the spirit of the biophysical environment) angry and cease to bring luck (Lavrillier, 2013). It is a traditional practice to establish social relations with individuals, nature and spirits in order to support livelihoods and to extend the family. It offers the possibility for marriage as a result of mutual land use by the community members, strengthens territorial and economic relations between nomads, and offers a means for the construction and support of ethnic identity. However, today various environmental and climatic changes, processes of urbanization and globalization, and related socio-economic changes have seriously challenged the custom of *nimat* (Sirina, 2012). Over the last five years, due to a decline in animal species, sharing rules have been changed and *nimat* tends to occur only among family members, rather than neighbors, relatives and close friends, as it used to. Today *nimat* is becoming more profit oriented in the context of a market economy. Some households even stopped employing the custom of *nimat* for economic reasons, selling the whole catch and earning some money to be able to purchase food and goods (Lavrillier, 2013).

3.2.3 Political and institutional change

Arctic communities have for centuries been resilient and able to adapt to a slowly changing climate thanks to their traditional knowledge. However, when it comes to drastic political, economic and other institutional transformations, their livelihoods are more vulnerable (Hendriksen and Jørgensen, 2015). If we follow the Russian history of the 20th century, we can define five major events when Arctic communities were significantly affected by political, economic and institutional change:

1) policy of collectivization in the 1930s;
2) the policy of "forced sedenterization of nomadic families" (Klokov and Khrushchev, 2010) in the 1950s;
3) the campaign against so called "unpromising villages" in the 1950s-1960s;
4) the Russification of the education system during the 1950s (Vakhtin, 1992);
5) the collapse of the Soviet regime in 1991.

The latter brought new challenges to the livelihoods of millions of citizens especially those practicing a traditional way of life. The break-up of the Soviet Union brought about a change in the economic activities of local people as they adapted to the new market economy (Davydov, 2014). State-run fishing and hunting companies became hamstrung after the termination of central subsidies, therefore local communities had to fall back on their own experience and relations with others (Ziker, 2002). The transition to a market economy inaugurated the establishment of new regulations by the Russian government associated with the subsistence practices. Since 2004, fishing has been restricted by quotas and closed seasons as well as by type, quantity and size of fishing gear (Federal Law 166, 2004), without, however, taking into account the local context (Nakhshina, 2012). These processes increase physical, social and cultural vulnerabilities of the Arctic societies which in turn may affect the sustainability of their livelihoods.

In summary, the fishing communities of Arctic Yakutia are facing significant challenges as a result of not only climatic and environmental fluctuations and trends, but also political and economic transformations.

3.3 Theoretical background, methods and research area

3.3.1 Vulnerability and Livelihoods

Due to the harsh climate and their remoteness Arctic local people have difficult livelihoods in general. Consequences of global change processes may increase the vulnerability of their livelihoods (Cannon and Müller-Mahn, 2010). The Sustainable Livelihoods Approach (SLA) is a tool to examine people's livelihoods in a holistic way. It highlights (poor) people's conditions of life, their opportunities and abilities towards gaining well-being, their vulnerability, resilience and livelihood resources, as well as the institutions

in which their livelihoods are embedded (Chambers and Conway, 1992). "A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets, while not undermining the natural resource base" (Chambers and Conway, 1992: 6).

Livelihood resources of Arctic people imply material assets such as natural (i.e. reindeer, fish, berries), physical (roads, snow mobiles) and financial as well as non-material resources such as human (traditional knowledge, health) and social (kinship, customs) (DFID, 2002; Carney, 2003). Current livelihood strategies (for indigenous people) encompass flexibility towards the availability of fish stocks, their mobility (change of fishing grounds, migration patterns), but also diversification (involvement in different economic sectors, change of consumption habits), and modification of fishing tools (Allison and Ellis, 2001, Scoones, 1998). Assets and livelihood strategies are affected by the political, environmental, and socio-economic context in which people live. Critical factors that impact on the sustainability of livelihoods, on the one hand, are vulnerability, which means people's susceptibility to an unstable ecological, social, economic or political setting, as well as organizational and institutional contexts (including policies, regulations and rules) (Rakodi, 2002). Sustainable livelihood strategies result in outcomes, which refer to improved material or non-material well-being (i.e. income, health) as well as reduced vulnerability (food security, sustainable use of natural resources) (Department for International Development (DfID), 2002). Moreover the framework helps to grasp how transforming regulations and policies affect local people's livelihoods. Furthermore, it helps in understanding the strategies these communities are adopting to cope with external shocks and transforming processes, in order to increase the sustainability of their livelihoods and their well-being.

Even though the sustainable livelihood framework (SLF), as initially defined by DFID, provides a good checklist for the assessment of people’s livelihoods and their institutional situation, it is criticized for being power blind and a-historical (i.e. Geiser and others, 2011; de Haan and Zoomers, 2005). While using SLA as an entry point for the purpose of this study, we are conscious of its issues and shortcomings. Therefore, we try to avoid the traps (Geiser and others, 2011) of the SLF and use the livelihood framework more broadly as an approach (SLA) that accommodates power relations and historicity in order to aptly assess vulnerabilities.

3.4 Methods

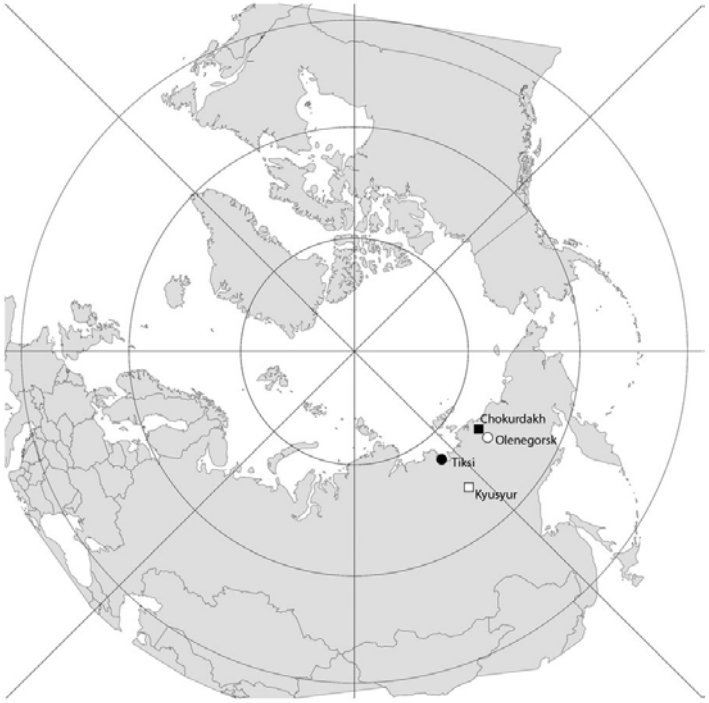
In order to assess our assumptions and test our hypotheses and to better understand Arctic livelihoods, their vulnerability to climate and institutional change, two methodological approaches were used in four Arctic settlements: 34 qualitative in-depth interviews with

indigenous inhabitants were carried out in 2014 and a quantitative standardized questionnaire with 204 local residents in 2015. In 2015, one of the villages could not be reached due to an unexpected early ice break-up that made transportation over land and on rivers impossible (a helicopter transport was not possible). Before conducting interviews, meetings with local municipality members were held in order to gain an overview of the research site as well as to select indigenous interviewees. We identified five categories of stakeholders: officials from local municipalities, key informants (i.e. fishers, hunters, reindeer herders), young people, elder people and public sector workers. Age distribution was planned to start from 18 years, however, due to summer vacations and general absence of the 18-26 age group, interviewees were between 27 and 84. Interviews involved male and female members of local indigenous communities – Eveny, Evenki and Sakha (according to the Russian definition Sakha are not indigenous, whereas they count as indigenous according to international standards). Interviews – that followed a guideline with topics, but tried to leave space for the respondents to choose their own pace and direction – addressed the following topics: subsistence activities of local people, perceptions of their environment and of the climatic and environmental changes in the area, as well as observed impacts of the climatic and environmental changes, and finally the influence of governmental regulations. The quantitative questionnaire, which mainly addressed questions regarding fishing for this study, was carried out face-to-face to avoid misunderstandings and to ensure all questions were answered. Respondents of different ethnic (not only indigenous but also local Russian, Ukrainian and others) and age groups were randomly selected. The questionnaire included Likert-scale answers regarding agreement to a statement, frequencies as well as yes-no and open questions. Moreover, selected expert interviews and participatory observation were carried out in the region, various community events were attended and some relevant grey literature and documents were collected. Interviews and questionnaires were conducted in Sakha or Russian depending on respondents' language proficiency and preference. Digital audio recordings of the interviews were made in order to reduce the risk of having inaccurate or incomplete data. The recordings were then transcribed and analyzed in MAXQDA software, in which transcripts were coded into categories in order to compare the data within these groups. Quantitative data was analyzed using SPSS. Besides analyzing frequencies we looked at differences between men and women, indigenous and non-indigenous people and respondents that lived for more than or less than 20 years in the area. We regard the different points of the Likert scale as equidistant intervals (for a discussion see Brown, 2011) and therefore are able to test for significant differences using Mann-Whitney-U-Test (for non-intervall answers a Wilcoxon test was used).

3.5 Arctic communities and research area

This study is based on two case study areas in North Eastern Siberia in the Russian Republic of Sakha (Yakutia), where Evenki and Eveny – both part of the Tungus ethnic group – and Sakha live (fig.9).

Figure 9: Location of the study sites in the Russian Republic of Sakha (Yakutia) (map by Florian Gerber)



The case study areas are located in four Arctic settlements of Chokurdakh and Olenegorsk in the Allaikhovsky *ulus*, and Tiksi and Kyusyur in the Bulunsky *ulus* of the Republic of Sakha (Yakutia), North-Eastern Siberia, Russia. These settlements are located in the delta of two large streams: Tiksi and Kyusyur on the Lena at the Laptev sea, Chokurdakh and Olenegorsk on the Indigirka at the East Siberian sea. Chokurdakh (70.6°N. 147.8°E) is located on the cape of *Chokuur Taas* (Flinty Stone), on the left bank of the Indigirka river. It is surrounded by Arctic tundra with abundant wildlife. It is an administrative centre of Allaikhovsky district with a population of 2068 people. Chokurdakh is an important air and river port. The site is populated by both indigenous and non-indigenous people who are mainly occupied in fishing (Rosstat, 2016, Nasledie Sela, n.d.). Olenegorsk (69.8" N, 147.5"E) is situated on the right bank of the Indigirka river. The area is classified as subarctic taiga. Olenegorsk is avillage with a population of 237 people mainly of indigenous origin: Eveny, Yukagirs, Evenki and Chukchees. Main activities of the villagers are reindeer herding, hunting and fishing (Rosstat, 2016, YuNN, n.d.). Tiksi (71.6°N, 128.8°E) is the capital of the

Bulunsky district and is the northernmost town of Yakutia. The town is surrounded by Arctic tundra. It is an air and sea port. Tiksi was founded as one of the ports of the Northern Sea Route. The population of Tiksi is 4556 people (Rosstat, 2016), both indigenous and non-indigenous, who are employed by the sea port, airport, meteorological station, reserve and so forth. Kyusyur (70.6°N, 127.2°E) is an ethnic village on the right bank of the Lena river, 120 km from Tiksi. It is dominated by subarctic taiga. The population of Kyusyur is 1272 people inhabited mainly by indigenous people (Rosstat, 2016). The economy of the village is agriculture, the locals are involved in fishing, hunting and reindeer herding. The selected areas are diverse because of varied levels of pollution and industrialization, environmental and climatic change and in this context they have different impact on people's livelihoods.

Indigeneity is a contested question in the Russian legislation. Officially it includes small-numbered ethnic groups with populations of less than 50'000 people whose traditional activities are hunting, trapping, fishing and reindeer herding (Slezkine, 1994, IWGIA, 2012). Russian legislation doesn't count the Sakha – another ethnic population of North-Eastern Siberia – as an indigenous community due to the size of the population and late advent to the region (IWGIA, 2012, Lehtola, 2012). However, international norms do recognize them as such advocating for the right of self-identification (Corntassel, 2003, Fondahl and others, 2015). This paper follows international norms and includes three ethnic groups in the studied Arctic villages when referring to indigenous people: Evenki, Eveny and Sakha. The Evenki and Eveny are indigenous Tungus-speaking communities mainly populating the Arctic regions of North-Eastern Siberia, Russia (Fondahl and others, 2015). In the Republic of Sakha (Yakutia) they comprise 1,61% and 2,25% respectively of the population (Rosstat, 2010). The Sakha are a Turk-speaking people widely settled in the Republic of Sakha (Yakutia) (Okladnikov, 1970; Pakendorf and others, 2006) where they migrated from Southern Siberia along the Lena river in the beginning of the 1200s (Crate, 2008). They are a titular nation of the region and comprise 49,91% of the total population (Russian Census, 2010). In this paper we will focus on the so-called "northern Sakha" who essentially differ from "southern Sakha" in their livelihoods, and are culturally more similar to the Tungus people (Wixman, 1984). The northerners mainly hunt reindeer, Arctic fox, sable and other fur animals and game; fish (Arctic cisco, *muksun*, Siberian cisco and many others), and gather berries such as blue berry, cowberry, cloudberry. In this study we concentrate on fishing, which is a strong indicator of change that affecting the livelihoods of Arctic people.

3.6 Results

Arctic people's livelihoods in Yakutia threaten to become more vulnerable due to recent changes in climatic and environmental conditions, alongside political and economic transformations. The livelihoods in the case study area are strongly associated with and

dependent on fishing. The following three subchapters are structured along the issues that impact local livelihoods with a focus on fishing: 1) perception of climatic and environmental changes; 2) fishing practices and changes in fish resources; 3) regulations and policies.

3.6.1 Climate and environmental change

Among changes in weather patterns respondents from all four communities mentioned warmer winters, colder summers and increasing unpredictability (for the summary of changes see table 2 below):

"It is warmer in winter now, which is very interesting. It was so cold in the past, that we used to start snowmobiles with a blowlamp or burnt clothes to warm the starter up" (M, 50).

"July used to be hot before. We used to play with the kids the entire summer... We often wore summer dress...But not now! It's getting cold, dramatically cold, and it is so windy" (F, 55).

"It is suddenly good weather, and suddenly there is a strong wind. It wasn't like that before. It is not stable now. One can never forecast what will happen when" (M, 66).

The respondents also reported the earlier arrival of spring, causing the river ice to break up earlier. Moreover, some community members observed later freezing, which hinders winter fishing:

"On the one hand, it is bad when the [winter] time arrives earlier. If it is late, the river freezes up late and it is impossible to catch a winter fish"(M, 50-60).

With regard to wind patterns, the responses are inconclusive, although most respondents noticed a change in the strength of the wind. However, some said it became stronger, some weaker. According to the respondents the weather has become more unpredictable with changing freezing and thawing patterns of the ice negatively impacting fishing.

Members of all communities stated that river levels have essentially increased and this was a reason for fish numbers to decrease. Moreover, as one of the respondents reported "*fishing grounds as well as lands where we used to collect sacks of wild leek, they are all under water*" (M, 51). However, sometimes the water level in rivers is too low and threatens ship transportation. For instance, in 2013, food and other commodities could not be delivered to villages along the Indigirka river for this reason. Some of the villagers observed changes in the riverbed, which are again expected to cause a decrease in fish numbers. Lakes are reported to have dried out over recent decades, with water bodies in some areas drying out whereas in others new ones appear. This happens due to thawing of the permafrost and largely depends on the underlying soil conditions: lakes dry up because downward percolation and evaporation are greater than re-supply by spring snowmelt and summer precipitation; and the

ground becomes water-logged due to the surface permafrost warming and the associated degradation of ground surfaces (ACIA, 2005, AMAP, 2012).

Shifting erosion and accumulation patterns remodel the riverbed and sand banks and cause fish to swim down to the stream bottom. River bank erosion occurs due to climate change related high water levels and permafrost thawing (ACIA, 2005). Fishers talked about river bank erosion which makes them use larger nets, despite this being prohibited by the fishing regulations, which stipulate the use of only certain types of nets: "*We used to employ seine before, but now we don't, because land is degraded, too many sandbanks, sort of islands, because water level is too low, hence we don't use seine, only nets. The land is degraded during the ice break-up, the ice forms sands, and the fish goes down, therefore we have to use wide nets, 7-8-9-12 m wide. According to law one has to fish omul with nets of 55 mm and Siberian vendace with nets of 30 mm. If nets are bigger, then you will be fined." (M, 50)* In turn, erosion is a serious threat to local people's property.

Table 2: Summary of the responses regarding climatic changes and impacts on the communities (own data and analysis)

Changes	Perceived impact
Winter temperature rise	Warm water regime
Weather unpredictability	Thawing and freezing patterns
Early arrival of spring	Accidents
Eary ice break-up	Accidents
Late freeze-up	Winter fishing
Change of wind direction/strength	Change of river bed
Water level fluctuation	Fish quality, white fish number decrease, parasites
Warm water regime	Fish abundance, distribution, extinction
Changes in the riverbed	Fish abundance, distribution, extinction
Drying out of lakes	Fish abundance, distribution, extinction
Erosion	Remodeling of river bed

3.6.2 Fishing practices and changes in fish resources

Participants of the interviews reported a significant decrease in caught fish. If in the past one could clearly see fish under the water while rowing, nowadays it is impossible they say; the fish hide in the lower reaches of the river where it is colder, or have moved further North. An interviewee reported that he could not catch a single fish during a longer time

period, which upset him greatly. He reported that the fish had gone somewhere and hidden at the bottom of the river or they had not yet arrived. The only fish villagers could find in their nets were pike, a predator. Predators are – in contrast to Europe for instance – regarded as of inferior quality compared to white fish and are therefore either thrown away or given to dogs. This attitude is based on the belief that these species eat (dead) meat not only from other fish but also from drowned people. Warm river water was pointed out as a possible reason driving fish movement to the bottom of a river or to the colder parts of the headstream. One of the elders said: "*We had many omul [Arctic cisco] before, one couldn't manage [with cleaning all of them], we did yukola [dried fish] but now not anymore. Why is there no fish? It's all because of the sand...the route of fish migration is blocked [by sand]"* (F, 76). Residents of Chokurdakh caught more fish with worms in contrast to villagers from Kyusyur who said that fish used to have worms before but nowadays they are clean and fat. Some respondents from Chokurdakh observed Siberian salmon which is not typical for their region and "*since it is a predator fish, it eats out broad whitefish*".

Table 3: Results from questions asked in the survey in relation to gender, ethnicity and duration of stay in the area (Source: Own data)

Question/statement	Answer type	n	Mean	Median	Std Dev	Gender	Indige-nous	Living > 20 y
Fish is a very important food source for my familiy	a	204	1.47	1	0.73	0.430	0,000*	0.001*
I need to consume fish everyday	a	204	2.16	2	1.14	0.159	0.006	0.007
Fishing is a relaxing activity	a	150	2.41	2	1.26	0.370	0.140	0.080
Fish is an important income source	a	150	2.78	2	1.00	0.744	0.072	0.892
Fishing grounds are spiritual places	a	152	1.9	2	1.14	0.173	0.054	0.023
Fishing is being in harmony with nature	a	154	1.62	1	0.80	0.127	0.002*	0.030
Fishing is a traditional activity	a	153	1.76	1	1.07	0.977	0,000*	0.019
Fish is a good way of socializing	a	151	2.02	2	0.98	0.092	0.199	0.118
They say the number of fish is decreasing	a	204	2.19	2	1.08	0.005*	0.085	0.143
How often do you fish?	b	203	2.64	2	1.50	0.076	0.076	0.003*
Do you share harvested fish with relatives or other people?	c	169	1.18	1	0.48	0.001*	0.374	0.001*
Do you get fish from relatives or other people?	c	203	1.43	1	0.67	0.196	0.204	0.204
Which option do you choose if you need fish?	d	204	2.2	3	0.983	0*	0.003*	0.087
How do the governmental fishing regulations impact on your livelihood?	e	188	1.4	1	0.682	0.083	0*	0*
If you do not catch fish, what measures will you take?	f	147	2.01	2	0.789	0*	0*	0*
What would you do with early freezing-up that renders fishing impossible?	g	119	2.25	2	1.173	0*	0.004*	0.047

a) Likert scale: strongly agree (1), agree (2), neutral (3), disagree (4), strongly disagree (5)

* significant at (at least) 5%

b) never (1), 1-2 x a year (2), 1-2 x a month (3), 1-2 x a week (4), almost every day (4)

c) always (1), often (2), rarely (3), never (4)

d) go fishing (1), go to store (2), ask relative/friend (3), do nothing (4)

e) problematic (1), they help me (2), other (3)

f) fish in another area (1), wait until fish arrive (2), ask the spirits (3), other (4)

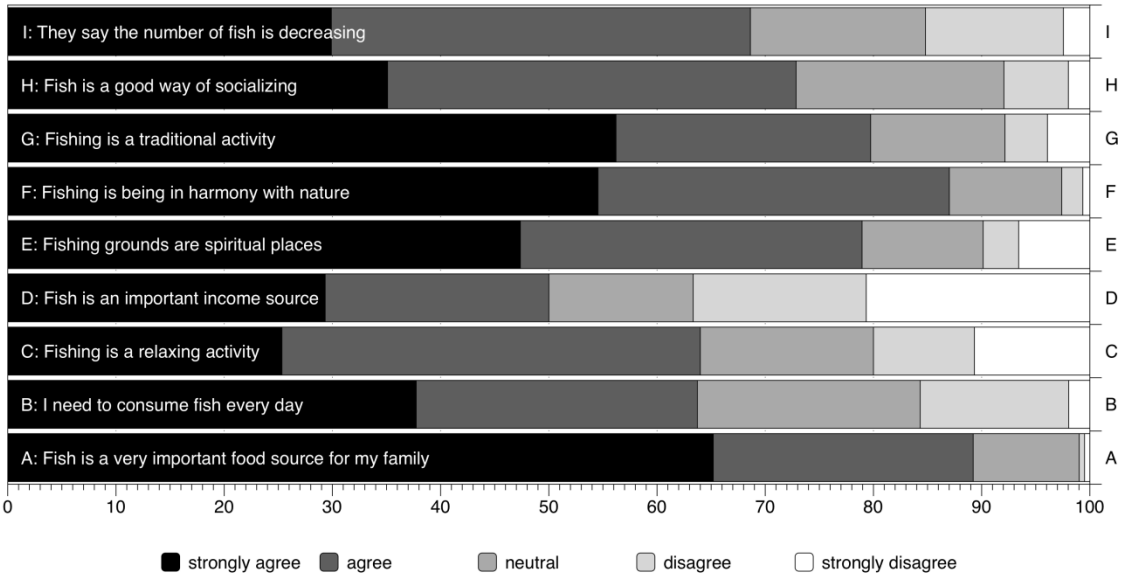
g) wait until it freezes (1), it is no hindrance (2), do nothing (3), other (4)

a-c are regarded as intervall scales and were tested with Mann-Whitney-U, d-g as ordinal scales that were tested with Wilcoxon

These different opinions are also reflected in the survey, where the mean value for the statement "They say the number of fish is decreasing" on a five point Likert item (1 for totally agree to 5 totally disagree) is 2.19 (see table 3). This means that on average the respondents agree with this statement while the value is close to the neutral value (3.0) with a standard deviation of 1.08 indicating that the opinions differ but not too greatly.

Interestingly, there is a significant gender gap (0.005 according to Mann-Whitney-U test), where women agree more with the statement than men. When considering duration of residency (category "Living > 20y" looking at residents that have lived in the area for more than 20 years irrespective of their ethnic origin) and between Eveny/Evenki and Sakha ("Indigenous"), however, there is no significant difference. Of the men only 7.7% never fish, with the women this value is 48.2%. More than 40% of the men fish every day or 1-2 times per week. Moreover, it becomes clear that fish is indeed rather important for indigenous people's livelihoods when looking at the means of the following statements that were below 2 on the Likert scale, which indicates an overall strong agreement (see fig.10).

Figure 10: Distribution of answers to statements on a Likert Scale (Source: own data)

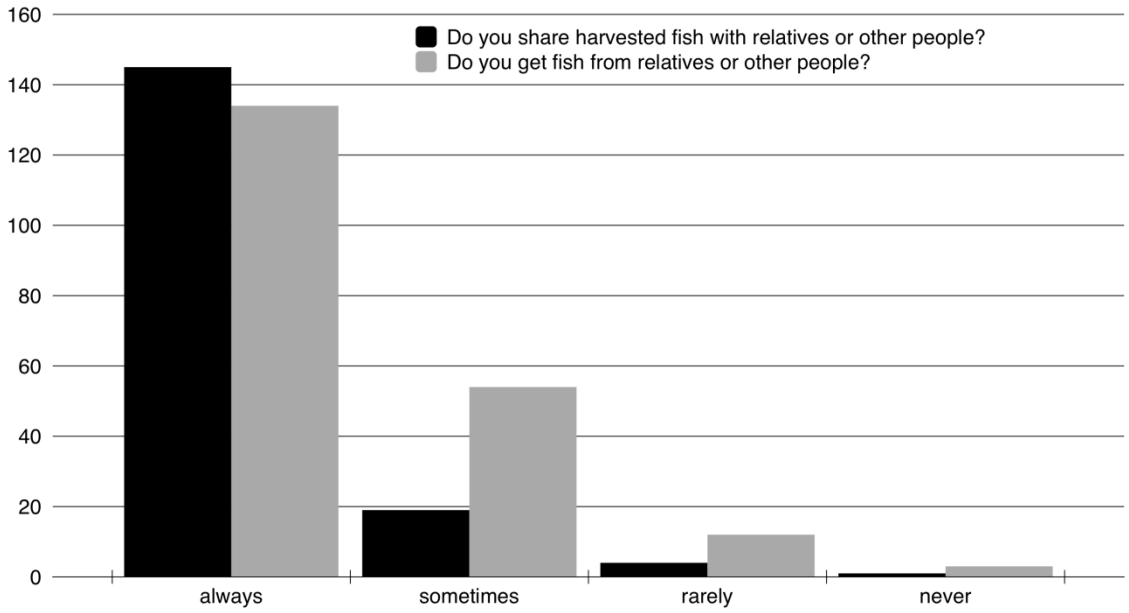


- "Fish is a very important food source for my family" (A in fig.10) (mean = 1.47). Obviously fish is an important protein source for Arctic families. The statement is supported ("strongly agree" + "agree") by almost all respondents. However, indigenous people and people born in the area or living more than twenty years there agree significantly more strongly ($\leq$0.001 according to Mann -Whitney-U test) with this statement. The same applies for the need to consume fish every day, which is

more important to indigenous (0.006) and long term residents (0.007) than others. Both these groups are also fishing significantly more than others (<0.001, 0.003).

- "Fishing is a traditional activity" (G; 1.76), is consequently also affirmed more strongly by indigenous people (<0.001) and long-term residents (0.019) as well as "fishing is being in harmony with nature" (F; 1.62; 0.002, 0.03), and (a bit less so) "fishing grounds are spiritual places" (1.9; 0.054, 0.023).
- Still affirmative but less strongly (means between 2 and the neutral value of 3) is the evaluation of the following statements: "Fishing is a relaxing activity" (C; 2.41), "fish is an important income source" (D; 2.78), "fishing is a good way of socializing" (H; 2.02), where there are no significant differences between the aforementioned groups. Hence, fishing is less important as a source for cash income than for subsistence.
- Most men state that they always (94.3%; see also fig.11) share their catch with others (*nimat*), while 76.5% of the women – who also fish less often – do this. The same applies to people living more than 20 years in the area, of which 91.7% always share, while others do this to a lesser degree (71.4%). Despite the differences it is clear that the vast majority shares always or sometimes and only very few share rarely or never. Figure 11 indicates a close relationship between people who fish together and those who receive fish from neighbors or relatives. However, the graph also shows that it is not a prerequisite to participate in a fishing trip with others in order to get fish from other people.

Figure 11: Questions related to *nimat* (Source: own data)



- If they do not catch fish, most respondents always (66%) or sometimes (26.6%) get fish from relatives or through *nimat*. When asked what they do if they need fish 36.8% give it another try, 49.5% ask friends or relatives for fish, and only 10% go to a store. The only remarkable difference is between genders, where 53.8% of the men give it another try and go out fishing once more and only 23% of the women do this while 58.4% of the latter ask friends or relatives (men 34.7%).

3.7 Fishing regulations and policies

The fishing regulations that were introduced after the collapse of the USSR presented the fishers with quotas and temporal limitations which were new to them. The quota is "a part of total allowable catch of water bioresources" (*Arcticle 26, Federal Law No.166-FS "On fishery and the protection of water biological resources,"* 2004) and is given per person or *obshchina* by a certain weight, which is not enough according to the interviewees. The weight may differ from year to year and settlement to settlement, depending on population size and many other factors. Quotas are allocated yearly by the regional officials in Yakutsk. Limitation means a ban of fishing for a month twice a year in spring and autumn, and thus "*make people starve*" (M, 70). Most (71.3%) of the respondents voiced the opinion that fishing regulations and policies are problematic for them, with only a minority 17.6% declaring that the regulations are helpful. Fishers stated that these regulations were established without taking into account conditions of the Arctic. Another concern of the local fishers was a restriction on size and type of fishing gear. According to respondents, the gear specifications are not adequate for Arctic conditions due to the size and weight of fish, therefore people would disobey regulations: "*When fishing, one must have a net of certain length, for instance maximum 25 m, and one can't use different nets, because their length is not appropriate*" (M, 53).

It is worth noting that fishing regulations are established by the Federal Government and then adapted to the local conditions by regional authorities. Yakutia belongs to the East-Siberian fishery basin, hence Yakutian fishers comply with this region's rules. Moreover, there are various federal and regional programs on fisheries development, social and economic development of the Arctic regions which are intended to create favorable conditions for fisheries' sustainable development and thus improve quality of northerners' life. However, these are long-term programs (until 2020) and the results are yet to come.

3.8 Adaptive strategies

Arctic local people have been adapting to a changing environment for centuries, and therefore have already developed their own coping strategies. The current adaptive strategy in the case of decreasing numbers of fish is finding new fishing grounds along the river. *"If there*

is no fish due to a river bed change, we move to another place where there is more fish" (M, 46). However, traveling to further grounds may be beyond local budgets as this requires more fuel, which is expensive (from informal interviews with local fishers). Therefore, most of the respondents reported that they *"will wait until fish arrive"*. In the event of a real fish shortage, fishers have to consume predator fish which, as was mentioned before, are regarded as being of inferior quality. However, local people have learnt how to cook pike or burbot cutlets from immigrants, so that these predator fish have become more popular recently.

The prevailing adaptive strategy to changes is out-migration. All the research sites have been partly abandoned and most of the houses in the villages are boarded up. The village of Olenegorsk used to have a population of 800 residents before the collapse of the USSR, nowadays it has only 250 people. As the villagers reported, many young adults migrate to bigger settlements in search of jobs or education. This could be related more to the social and economic situation rather than climate change. Extensive unemployment, high prices and low income force people (especially young people) to leave their homes. In contrast, elder people were against leaving their homes even in case of severe threat due to a deep attachment to the birth place.

3.9 Discussion

3.9.1 Climate change: the major stressor?

Every system becomes vulnerable when it is susceptible to a harm caused by a single or multiple stressors (Ford and Smit, 2004). Vulnerability can be of two origins: biophysical or social. Biophysical vulnerability is shaped by the physical event which makes the human system exposed (Brooks, 2003), social vulnerability is determined by the social, political and economic context which contributes to exposure (Ford and Smit, 2004). Thus, it is worth noting that Arctic communities are exposed to not only trends like climate change, but also to socio-economical transformations. In this section we discuss the stressors and their importance for fish resources as well as the subsequent impacts on the livelihoods of local people.

3.9.2 Vulnerabilities

Climatic and environmental change

The vulnerability of the indigenous and local people is increased due to recent climate and environmental changes. Even though the literature suggests climate change to be a slow and long-term process with a gradual impact (Schmidt-Thome, 2013), our findings demonstrate the opposite: climatic change and effects seem to be more pronounced in the Yakutian Arctic. Increasing winter temperatures, perhaps, are favorable for indigenous and local people's survival in the harsh environment, however it has a negative effect on their

fishing practices. A warmer climate alters freezing and thawing periods. Shifts in the timing and duration of ice-related events increases the rate of accidents with fishers and hunters in Lower Kolyma region of Yakutia (Mustonen, 2011; Shadrin, 2009). Similarly, inhabitants of Upernavik district in Greenland experience serious challenges due to late sea ice freezing. Usually, local people used to fish halibut by long line from the ice. However, now fishers have to mount long lines from open dinghies (Hendriksen and Jørgensen, 2015).

We compared respondents' concerns about increasing temperatures with meteorological records (fig.12, 13, 14). While autumn temperatures are increasing according to instrumental data records, those of summer look controversial. Many respondents claim summers are getting colder, but meteorological records show the opposite. A possible explanation for perceived lower temperatures could be increased wind chill. Instrumental records data is made on KNMI (n.d.), based on GHCN-D v2 data set.

Figure 12: Mean seasonal temperature trend recorded in Chokurdakh (also applies to Olenegorsk) (Source: KNMI)

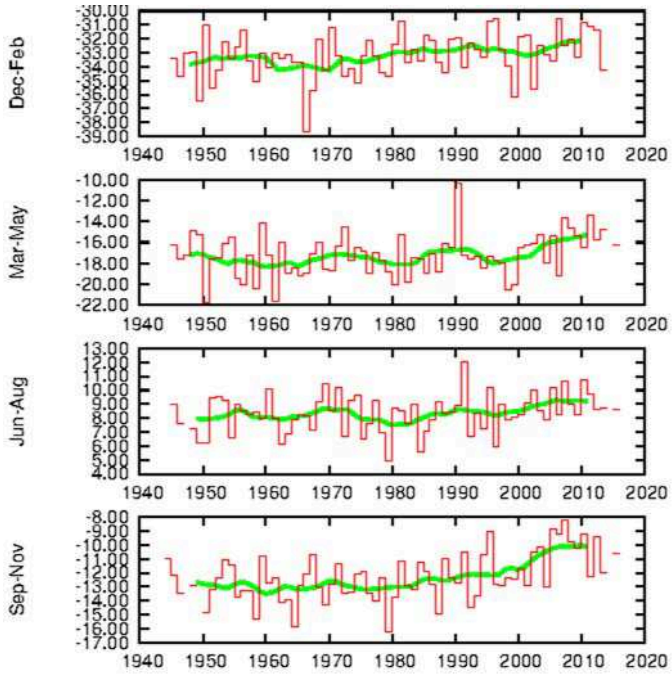


Figure 13: Mean seasonal temperature trend recorded in Kyusyur (Source: KNMI)

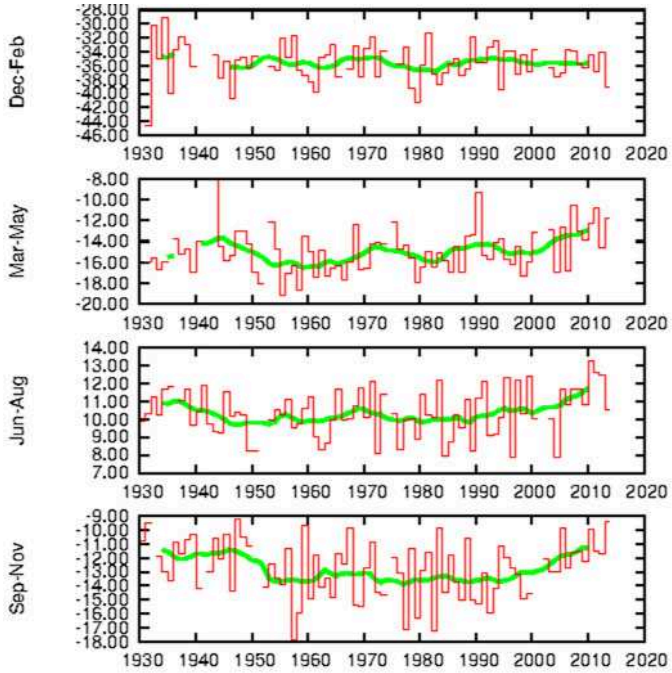
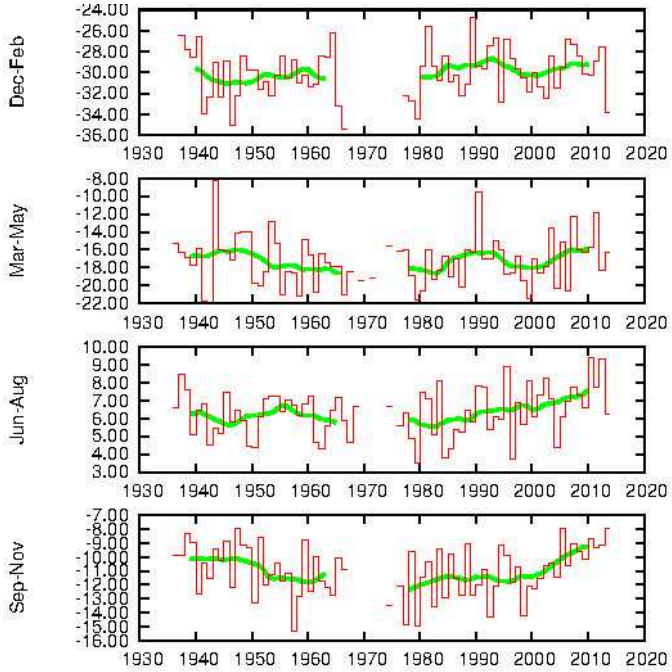


Figure 14: Mean seasonal temperature trend recorded in Tiksi (Source: KNMI)



Climate change alters the water temperature regime which may affect fish abundance (decrease or increase), and distribution or extinction due to the fact that fish physiology (growth, reproduction, activity) depends on temperature variations (Ficke and others, 2007). Therefore, warming water bodies in the research area may negatively affect the fishing activities of the local people and thus increase their vulnerability. Similarly fishers in northern Norway reported the effects of warming ocean temperatures on the distribution, behavior, and

type of fish caught: fish tend to go deeper to the riverbed if the water temperature is higher; and large amounts of southern fish species or unknown fish have been observed and caught in the region (West and Hovelsrud, 2010).

Fluctuations in water levels affect the quality of fish and cause a decrease in the numbers of white fish caught. Low water levels increase the number of parasites and associated problems (Reist and others, 2006). Perhaps this is a reason for respondents observing infected fish in the research areas. Higher water levels cause massive floods that result in sediment inputs smothering macroinvertebrates and incubating fish eggs (Nilsson and others, 2015). Local communities in Canada also observe fluctuations in water levels. Creeks, rivers and lakes are drying out in the region which causes a decrease in white fish numbers (Guyot and others, 2006).

Food insecurity

Impacts of climate change may be a serious threat to subsistence fishing which is a critical component of the local people's diet. Traditional food consumption is considered by local people to be more economically viable than buying in the shops; this is especially important when unemployment rates are high and wages are low (Nuttall and others, 2005). Therefore, an affordable way of making a living in the case study areas is traditional subsistence (i.e. fishing, hunting). Moreover, locally sourced food is crucial for people living in remote Arctic communities (Cochran and others, 2013) where the high transportation costs of fuel and other commodities may double or even triple the price. This is the case in the research area where food costs twice as much as in Yakutsk (for example, yoghurt in Tiksi costs 35 rubles, but only 17 in Yakutsk).

In the face of climate change, local communities are likely to experience challenges in traditional food availability, access and distribution. As a result this alters the intake of important nutrients such as protein, iron and zinc, of which white fish are a rich source (Guyot and others, 2006). One of the respondents noted that his teeth were in bad condition due to the consumption of "chemicals" from a store. Hence, switching to a more "western" nutrition increases the vulnerability to illnesses (risk of diabetes, obesity, cardiovascular diseases) (ACIA, 2005).

Likewise members of Inuit communities in Canada also reported to have experienced difficulties with traditional food consumption due to climatic and socio-economic stresses. Later and longer ice break-up, lighter ice, lack of pack ice during summer, higher temperatures and weather unpredictability made country food less available. Among socio-economic pressures, the locals mentioned poverty, high prices due to transportation distances, decline of traditional harvesting practices, increasing hunting costs (Beaumier and Ford, 2010).

Fishing policies

Environmental variabilities tend to be harsher when they interact synergistically with political, economic and other institutions in negative ways (White and others, 2007). After the break-up of the Soviet Union, fish emerged as a very important food and income source for many people since subsidies by the communist regime ceased to support Arctic people. Fishing was more reliable than hunting due to the lower expenditures required to do it. Davydov (2014) uses the term "free spaces" to characterize sustenance of a certain freedom of action by local people in relation to violation of fishing regulations. Local communities perceive these regulations as inappropriate and establish their own instruments to manage resources (Davydov, 2014). Many respondents in our study mentioned respect towards nature as a way of practicing their traditional activities, and disrespect, which is expressed in overharvesting for instance, may bring anger *Buga* and thus may deprive a fisher of luck. Therefore, local people would always follow their own unofficial (moral) rules in contrast to the official regulations: harvesting only a necessary amount of resources, feeding a land's or river's spirit before fishing, being silence in the nature while harvesting and so forth

Usually people perceive regulations established by the officials as inadequate for the local context (Nakhshina, 2012). During the Soviet regime the authorities usually provided local people with everything they needed, including transport and nets, because they were officially employed by the government. After the collapse, people were left alone and they had to transgress the law to survive. Interviewees emphasized the harsh climatic conditions of the Arctic, and since the legislation is designed for the entire North-Siberian region with its climatic differences, some articles of the regulation are unsuitable. For example, the spawning season of fish doesn't match with the fishing ban during spring or autumn in the research area. Equally, the required use of smaller fishing gear is inadequate for catching big fish.

3.9.3 Adaptive strategies

Adaptive strategies are based on previous experiences, positive or negative, and they are sort of a fundament for current adaptive mechanisms (Korel, 2005). Forced sedentarization of indigenous people during Soviet regime, separation of children from their families and growing up at residential houses broke down continuity of generations, passage of traditional knowledge and adaptive strategies (Popova, 2010). Popova (2003) in her research states that children primarily don't have positive value of their parents' life experience, 78,3% of indigenous children don't want to experience their parents' lives. This means devaluation of traditions, loss of adaptive potential to environment which have been transferred from generation to generation (Popova, 2003). This research clearly shows that traditional knowledge of adaptive mechanisms is gradually being lost. In combination with global change processes a loss of traditional knowledge about fishing and *nimat* decreases the

potential to adequately react to them and increases the vulnerability of indigenous livelihoods of Arctic peoples.

Many countries are developing various programs on adaptive strategies within longer-term perspectives. However, most of the rural communities think with a short-term perspective (often out of necessity): mitigation of current risks and vulnerabilities is a higher-priority task than developing policies for long-term coping strategies (Schipper and others, 2014). Hence, governmental regulations and policies, which are limiting subsistence activities, even though they are adopted for conservation purposes, are more important than climate and environmental change or programs of adaptive strategies.

3.9.4 Decline of traditional knowledge

Fishing is crucial for the social fabric of the indigenous people. *Nimat* as a cultural and social phenomenon tends to decline with the decrease of fishing culture as a result of climate change and restricted fishing regulations. This may also affect the whole system of the traditional culture of the indigenous people and negatively impact the most vulnerable people. Traditional knowledge and practices are passed from generation to generation. However, over recent decades, this knowledge is vanishing due to either the migration of younger people to urban areas or a reduction in the practice of traditional activities. For example, after the USSR collapse, reindeer herding has been gradually declining and it is now facing great challenges. The number of domesticated reindeer in Bulunsky *obshchina* of Kyusyur village has decreased from 13’000 head in the late 1970s to 2000 nowadays. On the contrary, fishing has been the only source of subsistence and cash income for the local people, especially since the break-down of the Soviet regime. Today, Bulunsky *obshchina* is experiencing hard times due to loss revenues mainly brought by reindeer herding and credit debts. Hence, it was decided to divide the *obshchina* into two joint stock companies: one for fishing and the second for reindeer herding. This meant assets sale and as a result a dissolution of the *obshchina*, which is the backbone enterprise. In this case this would also lead to the loss of the traditional activities as well as cash income.

Traditional knowledge among Sami young people in Scandinavia is declining too due to lack of interest in schools or witnessing of difficulty to conduct traditional practices such as reindeer butchering or cooking traditional food. Moreover, there are no possibilities to learn native languages in the natural setting as a result of lack of linguistic resources or native students, therefore indigenous languages are gradually dying out (CBD, 2006). Native language is a mean of traditional knowledge passage whether through vocabulary associated with animals and plants or landscape characteristics (Fondahl and others, 2015). Hence, it is tremendously important to speak indigenous language to be able to transfer traditional knowledge. In the research sites very few of interviewed could communicate in their mother

tongue: for instance, in the village of Olenegorsk, only around 10 inhabitants out of 237 spoke Eveny language, and they were elders. Elder inhabitants of the research areas were concerned about the decline of traditional practices due to a lack of and shift of interest from younger generations as a result of harsh working conditions as well as low income level, hence most of the youngsters migrate to urban settlements in search of working possibilities.

3.10 Conclusion

Fish is an important traditional food, subsistence economy and social fabric for the local people of Arctic Yakutia. However, over recent decades numbers of caught fish have significantly decreased. Local and indigenous people attribute decline in fish species to climatic and environmental change: high water levels, increasing water temperatures, changing migration routes. However, these variabilities are not the only factors hindering the fishing practices of the local and indigenous people. Fishing regulations present important obstacle to the Arctic people. Local communities have developed adaptive strategies to a changing environment. While traditional adaptation of fishing techniques to seasonally changing conditions might increase the adaptation potential to future conditions under climate change, fishing regulations appear to limit this potential. Hence, we can conclude that the co-occurrence of the stressors of climate change, the shift from a planned to a market economy, and new fishing regulations strongly increase the vulnerability of the local people. While adaptation to one stressor seems manageable, facing multiple ones is problematic.

4 Awkward relationships with the melting Cryosphere

This chapter is part of an unpublished publication with several co-authors. The section on food insecurity in the Arctic of this chapter represents the contribution of Stanislav Ksenofontov to this publication.

Food (in)security: awkwardness of governance

Climate change is challenging the security of indigenous peoples, bringing awkward challenges to governance. In the Arctic, food security, especially the security based on natural resources in the environment of indigenous peoples, is influenced by climate and environmental changes as well as other external stressors such as sociopolitical, economic and institutional transformations. Natural resources are crucial assets to Arctic indigenous peoples for subsistence, trade and social cohesion and indigenous communities have relied on resources such as fish, wild mammals, birds and plants for their centurieslong histories. This is a reality threatened by state change where often governance mechanisms merely exacerbate the disjunction between man and the environment.

The effects of climate change are a serious threat to traditional practices of Arctic indigenous peoples. Melting ice layers in the Arctic Ocean, flooding of lowlands, permafrost thawing, increasing numbers of lakes cause significant changes in the composition of animal and plant species and diversity. The natural habitat of various species expanded to the north and local species are forced out by better adapted newcomers (Omann et al., 2009). As a result, this will lead or has already led to a decline of traditional harvesting activities and due to a scarcity of edible wild plants Arctic indigenous people increasingly rely on hunting wild game (CAFF, 2013). However, Arctic indigenous peoples have been always flexible and

[6] For an excellent ethnography of severe climate change impact in the north, see Elizabeth Marino, Fierce Climate, Sacred Ground: An Ethnography of Climate Change in Shishmaref, Alaska (Fairbanks: University of Alaska Press, 2015).

[7] Eduard Zdor, personal communication, April 2015. For further discussion, see Igor Krupnik and Dyanna Jolly eds., The Earth is Faster Now: Indigenous Observations of Arctic Environmental Change, (Fairbanks: Arctic Research Consortium of the United States, 2002).

adaptable to environmental changes over centuries (ACIA, 2005). The question is what options they have to adapt in the face of multiple and rapidly occurring changes.

A significant challenge to food security includes that the high rates of unemployment and the fact that in low cash income communities, traditional hunting and fishing practices are economically more feasible than buying foodstuffs in the store (Nuttall et al., 2005). Additionally, due to long transport distances in Polar Regions, storebought food is often of low quality, very costly and varies in availability (Beaumier and Ford, 2010). Although they primarily enable subsitance lifestyles, natural resources serve as an important cash income source. For example, smallscale fisheries of Arctic Yakutia in NorthEastern Siberia provide 73% of the whole catch of the region (Totonova and Sleptsov, 2014). The resources of the natural environment are not only a space of harvesting, but they are also key for social, cultural as well as spiritual identification and cohesion. Traditional myths, a lively folklore as well as celebrations and rituals demonstrate the strong social, economic and spiritual relations of indigenous people with their environment, a reality which is under threat.

Despite their previous longterm resilience to environmental changes, there are additional stressors limiting the potential of indigenous communities to continue adaptation, including sociopolitical, economic and institutional changes. The introduction of "Western" lifestyles, new diseases and dietary regimes, formal learning, Christianity, and sedentarization have decreased the ability of Arctic indigenous peoples to sustain traditional ways of understanding and communicating with their environment. Modern conservation practices coupled with higher industrial land uses ignore traditional ways of living in the Arctic region (CAFF, 2013). These effects are felt around the circumpolar Arctic.

For example, in the Siberian region of Yakutia, local fishers were able to adapt to environmental and climatic changes, but they are unable to control the legal system of the central administration. Thus, the fishing legislation – installed against overfishing – is considered to be inappropriate and hindering the local fishers' ability to sustain proper fishing activities. The issue is that this regulation was established for the entire NorthSiberian region with its considerable environmental and climatic differences. For the harsh climatic conditions of Arctic Yakutia some articles of the regulation policies are incompatible (Ksenofontov et al., 2017) with local subsistence management and practices.

In the Western Arctic, the story repeats. In Greenland the fishers and hunters of Upernavik region, who possess high adaptive capacities to climate change due to their centuriesold traditional knowledge, are challenged by the legislation of their respective governmental authorities (Hendriksen and Jørgensen, 2015). In Nunavut in the Canadian Arctic, indigenous Inuit womens' food security is exacerbated by the external socio-political and economic stressors such as high prices, availability and low quality of store food, poverty, limited knowledge about how to process store food, substance abuse and gambling, high

hunting expenses, and lack of money management (Beaumier and Ford, 2010). These examples demonstrate quite well the neglect of the traditional knowledge and rich experience of indigenous people in the policy making processes. Moreover, some governments are reluctant to be engaged in solving socially, economically important issues of the local people.

It is the coupling of climate change with socio-political, economic and institutional transformations that compromise food security of the Arctic indigenous communities, and thus increase their vulnerability. With diminished food security, there might also be threats of the decline of traditional knowledge, traditional practices and even extinction of the entire groups. It is this state change that creates awkwardness in the relationship between indigenous communities and food security as they face the increasing challenges of making the Arctic home. Therefore, in order to preserve vulnerable indigenous cultures, indigenous knowledge systems should be systematically taken into consideration in conservation and climate change adaptation policies.

5 Synthesis

5.1 Main findings

This PhD thesis has analysed vulnerability and adaptive capacity of Arctic social-ecological systems to the effects of global change drivers by studying local people's perceptions of environmental change impacts on biodiversity and their livelihoods, relation of global change drivers to perceived biodiversity changes as well as consequences of cryosphere change in the Polar regions. This last chapter summarizes main findings of the study by discussing research questions, theoretical as well as empirical contributions, and highlights future key considerations and directions of the research.

5.1.1 Local people's perceptions of environmental changes and relation of global change drivers to perceived changes in biodiversity

In addressing the first research question (RQ1) **"Which changes do local people perceive in their environment and how do they relate global change drivers to perceived changes in biodiversity?"** in chapter 2, the thesis has assessed the vulnerability of the Arctic biodiversity to the effects of global change drivers from the local people's perspective as well as relations of observed changes to global change drivers. In answering the research question the chapter first of all introduces an ecological system of Arctic Yakutia, its biome, floral and faunal composition. Then it draws attention to the use of biological resources by local and indigenous people essentially for hunting, fishing, gathering and reindeer herding as a source of subsistence, income, social cohesion and cultural identity. The chapter then states that these traditional practices are significantly affected by global change drivers such as climate change, land use and technology adaptation, overexploitation.

The thesis has shown that among climatic changes local people perceive increased winter and decreased summer temperatures, higher levels of precipitation, higher water levels in some years and contrarily low water levels in others, early river breakups and late river freeze-ups. All these fluctuations have a significant impact on Arctic biodiversity. Warmer winters and high snow levels hinder reindeers' access to food, higher water levels cause fish to go down to the river bottom, low water levels affect waterfowls, early ice breakup challenges reindeer migration. Climate change enables the arrival of new, boreal species to the region such as wolves, bears, sables, mallard, shoveler, dandelion, chamomiles and others. It affects the abundance of local species, some of which are increasing (i.e. swan, Siberian crane), or decreasing (i.e. ducks, geese). Moreover, the vegetation cover has altered as a result of climate change. For example, trees become lush in some areas whereas a number of plants face decline. Local communities regard the utilization of heavy equipment and vehicles as tremendously disturbing the biodiversity of their environment. Thus, reindeer migration routes have shifted as a result of technological development in the region. In addition, plants have been devastated by the abundance of ATVs (all-terrain vehicles), combined harvesters

and other vehicles. Hence, technological development resulted in overexploitation of natural resources.

Local people attribute biodiversity change to global change drivers: climate change, land use and technological adaptation as well as overexploitation. Climate change is believed to be a reason of the new plants' habitat shift, heavy growth of trees and bushes, fish and birds scarcity, decline in the amount of berries. Land use and technological adaptation destroy lands and vegetation from the local people's point of view. However, technological adaptation has a positive effect as well. Forest growth is associated with the termination of tree cutting and development of the oil heating system. Technological adaptation facilitated the excessive use of vehicles and travel to further areas for hunting and fishing and thereby brought about additional overexploitation.

Similarly, forest fringe communities in the Indian Eastern Himalaya perceive that climate change may decrease fish catch and collection of non-timber forest products (NTFP) for medicinal or consuming purposes. However, fodder and fuel wood gathering from the forest have not decreased because the forest is the only source of domestic energy and fodder (Dey et al., 2017). Indigenous communities in Nigeria conceive environment as changing due to human activities and predominantly impacting on health, food supply, biodiversity and fuelwood. Furthermore, climate change affects mainly poor people who highly depend on natural resources (Ishaya and Abaje, 2008).

5.1.2 Impact of global change drivers on vulnerability of the local people's livelihoods

In addressing the second research question (RQ2) **"Which global change drivers impact on the livelihoods of local people and their vulnerability"** in Chapter 3, this thesis views livelihoods through the lens of fishing activities and focuses on the vulnerability context of the fishing communities of Arctic Yakutia in the context of global change. In doing so, the thesis firstly depicts types and specific techniques of fishing activities as well as it stresses the importance of fishing as a food, income and social fabric sources for local people. Thus, in Russia fishing is divided into six types, however the thesis takes into account only two of them which are the target practices within the scope of this study. Fishers utilize five different techniques to catch fish: ice-fishing with nets, winter fishing under the ice with a short rod, spring thin-ice fishing, open-water net fishing and seine (*nevod*) fishing. Fishing is a crucial source of food, income and social fabric as it was mentioned above. Indigenous and local people consume fish as a source of vitamins and nutrients since it is expensive to rely only on store bought foods due to socioeconomic reasons (high transportation costs, low income, high unemployment rate). The same socioeconomic factors result also in the involvement of the local communities in fisheries which generate some income. Fishing plays

an important role in constructing social relationships among local people and in maintaining a spiritual connection with their natural environment.

However, over the last decades local people's livelihoods are increasingly becoming vulnerable as a result of environmental and climatic changes as well as political transformations. Therefore, this thesis assesses effects of global change drivers to the vulnerability of local people's livelihoods. It has been revealed that local fishers observe drastic climatic and environmental changes, which are significantly affecting their fishing practices: warmer winters, colder summers, weather unpredictability, earlier arrival of spring, later freeze-up, earlier ice break-up, higher river level, altered river bed and erosion. All these fluctuations have an impact on fish abundance and distribution. Thus, in recent years the numbers of native white fish caught are decreasing while the numbers of exotic fish, in contrast, are increasing. Arctic fish, accustomed to a cold environment, are not only migrating away up to the colder streams, but are also going deep down to the river bottom where they – according to the respondents – find warmer waters. Climatic and environmental changes may increase vulnerability of local livelihoods in terms of higher rates of accidents.

Another important driver that affects the livelihoods of local people are political transformations occurring after the collapse of the Soviet Union. Since this chapter deals with the fishing communities, it covers fishing regulations that were meant to protect fish resources restrict traditional activities. Thus, the livelihoods of local fishing communities are constrained by quotas, temporal limitations and specifications of fishing gears. Moreover, the quotas are considered as badly adapted to traditional fishing. In turn, these constraints increase vulnerability of local people's livelihoods by limiting their access to fish. This case shows that trends such as the changing climate indeed are impacting on traditional resource use and therefore increase the vulnerability of local communities at least temporarily. This not only due to decreasing fish quantities and qualities, but also for the fact that a traditional custom (the sharing of fish) is decreasing as a consequence. Moreover, the fishing regulations that came as a surprise to the fishers (and thus can be regarded as "shock") pose a different challenge for them that they have more difficulties to adapt to. Hence, the combination of climate change and changing policies that are regarded as detrimental to the people's livelihoods makes them and their SESs more vulnerable.

5.1.3 Adaptive strategies of the indigenous and local people to cope with the global change impacts

This thesis has demonstrated how indigenous and local people adapt to the global change impacts. In answering the third research question (RQ3) **"Which adaptive strategies are employed by the local people to cope with these impacts?"** the thesis has shown that the indigenous and local people have developed adaptive strategies to global change impacts

and have been successfully utilizing them over centuries. Thus, indigenous and local people change their fishing grounds in the case of fish shortage. However, it is not feasible for some fishers to employ this adaptive strategy due to high prices of necessary supplies (mainly fuel). Therefore, some fishers would wait for the fish arrival to the fishing grounds. Indigenous and local people change their consumption habits in response to fish numbers decrease by consuming "foreign" fish which is considered to be of inferior quality and culturally inappropriate. The thesis has revealed that migration has become one of the prevailing strategies to cope with socio-political and economic transformations. Most of the young residents have left their homes to bigger settlements in search for a better life. This, in turn, may result in the decline of traditional knowledge about adaptive strategies as well as traditional practices as their transfer from the older generation to the younger ones may be terminated. Consequently, the vulnerability of local fishers increases and the future sustainability is endangered.

These findings are in line with the meta-analysis of Savo et al. (2017) of adaptive strategies of the subsistent-oriented fishers from across the globe which have been extracted from 162 studies in 49 countries. The report revealed that changing fishing grounds is one of the possible options for fishers in other regions of the world. However, it largely depends on the availability of alternative fishing areas determined by the access to such grounds and spread of climate change. Likewise, traveling to other fishing grounds burdens fishers with more expenses for fuel and other supplies. As a result of the unavailability of fishing grounds, some fishers are forced to leave their homes to other regions or even countries. Thus, migration is also one of the prevalent adaptive strategies to climate change and similar to this thesis findings, it has a negative implication for the social fabric and traditions' passage of the local communities. In addition, fishers in some regions adapt to fish shortage by diversifying food sources as this thesis has also demonstrated.

5.1.4 Impacts of the cryosphere change on the political, social and territorial relationships that shape Polar regions

Research question four (RQ4) **"What is being lost and revealed in the melting cryosphere and what is the impact on human relationship with the Polar regions"** is addressed in Chapter 5. The chapter is based on a contribution to an interdisciplinary discussion of historical context, territorial arguments over sovereignty, different definitions of the Arctic and the role of place attachment, the effects of the melting cryosphere to the poles, ecosystems and indigenous livelihoods, physical remnants of human presence as well as military and scientific interventions to the Polar regions. It demonstrates how the food security of local indigenous communities is compromised by the coupled climatic change as well as socio-political, economic and institutional transformations.

The chapter has demonstrated that the melting cryosphere has affected ecosystems of the Polar regions: polar bears are threatened to die-out, walrus lack ice, rivers and lakes dry out. The melting cryosphere provides new opportunities for scientific research through easier archeological access, emerging commercial activity through tourism and trade, but also enables vandalism and theft, destruction of archeological sites as well as illegal access. For example, thawing soils make it possible to excavate mammoth ivory, which damages the archeological heritage of the Arctic. Oil extraction and marine transportation development may bring about harm to traditional practices of natural resource harvesting. The melting cryosphere has revealed physical wastes once left by humans: vehicles, ration cans, the supplies and other trash of the anthropogenic military or other activities in the polar region. The changing cryosphere may also create challenges for governance, especially in climate governance. Because in decision making on adaptation action and other climate change related issues it is necessary to consider actors who belong to the Arctic and that are dependent on natural resources. One of the serious consequences of the state change is "climigration" – climate change induced migration. Even though it is considered to be an appropriate adaptive strategy to climate change, it has multiple negative implications for social and cultural well-being. It both decreases vulnerabilities if the financial assets can be increased and increases them by disrupting social networks and decreasing traditional knowledge. Moreover, the changing cryosphere challenges the food security of the local people. Climate change related alterations such as increased temperatures, floodings, permafrost thawing result in an expansion of invasive species and shift of native species' habitats. This leads to decline of traditional food harvesting and consequently increases food insecurity of indigenous people.

5.2 General contributions

This thesis contributes to the understanding of four main topics: 1) climate change in Arctic Yakutia; 2) indigenous and local knowledge related to global change and its impacts on social-ecological systems; 3) sustainability of social-ecological systems; and 4) the integration of SESs and SLA.

Climate change research related to (indigenous) people's livelihoods in the Arctic is widely carried out by anthropologists and social scientists in Canada, Alaska and Nordic countries (ACIA, 2005; Berkes and Jolly, 2001; Ford et al., 2006, 2008; Krupnik and Jolly, 2002; among many others). However, inquiries in Siberia are much less conducted than in other Arctic regions. Few examples address Nenets and Sami in Northern Russia (Nuttall et al., 2005), Yamal Nenets in Western Siberia (Forbes et al., 2009; Stammler-Gossman, 2010) and a few studies on Yakuts (Crate, 2008, 2013; Takakura, 2015), taiga Eveny and Evenki (Lavrillier, 2013), Chukchi and Yukaghir (Mustonen, 2011) in North Eastern Siberia. Studies

published in English on climate change in Arctic Yakutia are limited, therefore this thesis fills the research gap in this regard. Moreover, there is a scarce literature on contemporary climate change perceptions among tundra as well as forest tundra Eveny and Evenki populations in the proximity to the Arctic Ocean.

Indigenous and local knowledge of climate and environmental change is gradually gaining broader recognition in Western scientific literature (Green and Raygorodetsky, 2010). It may broaden the understanding of climatic and environmental change in the Arctic and complement existing scientific knowledge (Riedlinger and Berkes, 2001). Studies on indigenous and local knowledge are growing globally, however, there is still a lack of research in the Russian Arctic, especially in Yakutia. Therefore, this thesis provides in-depth insight into indigenous knowledge of Arctic Yakutian communities about climatic and environmental changes and impacts on social-ecological systems. Furthermore, major assessment reports on climate change impacts in the Arctic such as the Arctic Climate Impact Assessment (2005), Arctic Monitoring and Assessment Programme (2012), Arctic Biodiversity Assessment (2013) lack scientific and indigenous evidence of biodiversity change in Arctic Yakutia except for few mentions.

Based on my findings in Arctic Yakutia I conclude that while climate change is strongly impacting on indigenous and other local people's livelihoods, they perceive their social-ecological system as something that is ever changing. This enables them to actively adapt to changes relying on their traditional knowledge even though the circumstances are not well known by them. However, with other aspects of global change such as pollution and degradation through machines and infrastructure as well as the integration in global market schemes they have more difficulties to adapt. Outmigration is – as in many other poor communities – often the only strategy to cope. Compared to other Arctic people those who have experienced a communist system with a state directed economy, such as in the Soviet Union, faced other challenges. My research shows different ways of how people dealt with the system – that also heavily subsidised Arctic communities – and especially with its demise. Some villages swiftly tried to restore (or reinvent) traditions, including their language (that was suppressed before). Others did not go this way. Hence, when it comes to policies that impact on Arctic people's livelihoods, their (potential) heterogeneity needs to be taken into account.

The thesis adds value to the emerging Arctic sustainability science. One of the priority tasks of the ICARP III (2016) report is the understanding of sustainable development of the Arctic social-ecological systems. According to the report it is important to focus on the sustainable harvesting and management of natural resources, effects of extreme weather events to social-ecological systems, climate change and anthropogenic impacts on biodiversity and implications for ecosystem services and societies, institutions' role as a factor

influencing sustainable development (ICARP, 2016). The thesis addresses all these above-mentioned issues and will make an essential contribution to the ICARP agenda. In addition, research on the sustainable development of Arctic populations has been prioritized in the agenda of several key Arctic scientists (Petrov et al., 2016).

If we look at the example of fishery we can conclude that sustainability is at stake when fish numbers and quality change through the impacts of global change. I did not assess fish stocks, however, the fact that fishers are uneasy as how to cope with these changes (although most are confident that they can somehow). In the traditional fishing practices of the Evenki, Eveny, Yakuts, the knowledge was embedded of how many caught fish were enough to keep a stable and sustainable stock. Also, the practice of sharing fish with other (often more needy) people was part of this. In my research I was able to see that by the adaptation of these practices to the observed changes this knowledge and habit is increasingly lost with (potentially) negative consequences to the environment and to social cohesion.

The concepts of SLA and SESs are widely utilized in the social sciences across many disciplines, at different scales and applied in many different regions of the world. However, integrative research on combined SLA and SESs is limited, especially with regards to the Arctic setting. Therefore, the thesis contributes to the understanding of the vulnerability context of social-ecological systems in the Arctic by combining two different concepts of SLA and SESs. Moreover, the two concepts have not been applied to this thesis' case study area before and thus the thesis is the first research product to employ the two combined concepts. This may make a significant contribution to an interdisciplinarity of social-ecological systems and global change research. The two concepts have been integrated to the Arctic context by employing some core elements of the both concepts (from SLA: vulnerability context, social and natural capitals, transforming structures and processes; from SESs: resource system and units, resource users, resource governance, interactions and outcomes). This helped me to understand the vulnerability of social-ecological systems from both anthropocentric and holistic perspectives. This means that the integration of SLA and SESs is useful in assessing both social and ecological systems from two different angles. I believe that the two integrated concepts may be employed in other settings to examine the vulnerability of other social-ecological systems, for example, indigenous livelihoods in the rainforest of the Amazon, who may also be susceptible to the global change drivers.

5.3 Key considerations and future directions

This thesis offers not only main findings and significant contributions in line with the international Arctic roadmap of the ICARP (2016) (sustainable harvesting and management of natural resources, effects of extreme weather events to social-ecological systems, climate change and anthropogenic impacts on biodiversity and implications for ecosystem services

and societies, institutions' role as a factor influencing sustainable development), but also suggests key considerations and future research directions to focus on.

5.3.1 Key considerations

The research on vulnerability of social-ecological systems stresses that involving indigenous communities and assessing indigenous issues should be done in a participatory and transdisciplinary way and performed employing bottom up approach. It should engage indigenous and local stakeholders in research design and implementation in order to tackle as many issues as possible. Top-down research may distance local communities from an active participation and fail to encompass issues crucial for local people under research (Fraser et al., 2006). Bottom-up research encourages meaningful participation of local communities and thereby provides invaluable insight into the issues (Nyong et al., 2007). Even though this study has been designed more or less in a top-down fashion, the implementation has considered social, economic and political factors that affect local communities. Furthermore, the thesis is designed and implemented by an indigenous researcher who is familiar with the environmental and socio-political setting of the research sites. Indigenous worldviews and transfer of traditional knowledge, culture and skills from generation to generation are considered the major sources of sustainability and resilience in Arctic communities (Vlasova and Volkov, 2016). Scientific knowledge at times is unable to fully understand social-ecological systems as a whole. Therefore, it is crucial to integrate indigenous and scientific knowledge by actively engaging indigenous communities through transdisciplinary approach. However, there are also some disadvantages of being indigenous while interviewing indigenous people (especially concerning certain sensitive issues). One of such disadvantages is the lack of neutral position as a result of close mental proximity to the indigenous people and similar perceptions of specific questions. Therefore, it is essential to distance oneself a little bit in this regard to gain unbiased understanding of the topic as an "external" scholar would do.

Most of the social-ecological studies have been carried out at the regional scale (Fischer et al., 2015). However, to better understand social-ecological dynamics in the globalized and interconnected world, it is necessary to conduct research at larger scale across regions. For example, it would be interesting to carry out a comparative analysis of the social-ecological systems of Greenland and Arctic Yakutia whose indigenous communities are similar in many ways: reliance on natural resources, traditional practices, social problems, environmental issues and so forth. The larger scale research may also be useful practically in applying local policies associated with social-ecological issues to other settings.

One of the critiques of the social-ecological systems concept is its lack of the time scale. Thereby, it is essential to consider the historical context of social-ecological dynamics

to better understand the current status of social-ecological systems. In doing so, it is necessary to examine the foundation and development of social-ecological systems over time and through a historical lens.

Apart from theoretical and methodological considerations, the thesis offers to take into account following practical nuances. First of all, seasonal transitions in conducting field trips. I went to my second field trip in the springtime, which was not optimal. I was confident that the trip to all the research sites would take place without any substantial problems and that I could cover all four sites. However, as a result of an earlier than expected river breakup (which can be related to climate change – ironically a topic of my research), I could not reach one of the villages along the Lena river in the Bulunsky *ulus*. The cars were not utilized anymore at that time due to earlier melting of the river, and I was suggested to travel by snowmobiles. But the snowmobile drivers refused to take on the responsibility for my safe and sound trip since it was my first time to ride a snowmobile. Therefore, I would take into account this factor and conduct a field trip beyond a transitional season. Secondly, in order to avoid unnecessary stress and possible loss of data, it is advisable to exclude sensitive issues from the written questionnaire.

Outreach plays a crucial role in disseminating research results and raising awareness among community members. Therefore, it is important to hold workshops to report study results back to participants. However, it requires additional funding to carry out such activities. Alternatively, media reports or digital distribution of the research findings will make more sense in the context of financial shortage. Policy briefs to inform decision makers about the research results and implementation recommendations will be useful to local communities. Hence, the thesis may contribute also to the local society.

5.3.2 Future directions

One of the key research priorities in the Arctic is "examining the role played by equity, agency, power and justice along key axes of difference in the Arctic, i.e. gender, age and identity" (ICARP, 2016). Even though the scholarship on gendered climate change is growing, it is still generalized (Bunce et al., 2016). Studies on gender and climate change are well represented in Sub-Saharan Africa and emerging in Asia (Bunce and Ford, 2015), however there is limited knowledge of the gender dimension of vulnerability and adaptation to climate change in the Arctic (Petrov et al., 2016). In the Arctic gendered climate change vulnerabilities are expected to be quite different (Ford et al., 2012). For example, members of Inuit communities who are involved in male-dominated traditional activities such as hunting and fishing are more vulnerable to climate change (Cunsolo Willox et al., 2012). Similarly, indigenous women are vulnerable to effects of climate change as a result of violation of their rights to territory and natural resources as well as patriarchy, to name a few factors (Prior and

Heinämäki, 2017). Therefore, it is critical to expand our understanding about gender differences in perception and actions associated with drastic social-ecological transformations.

In the Republic of Sakha (Yakutia), gender studies mainly encompass issues associated with the demographic behaviour of men and women, employment and unemployment, education, ethnocultural aspects of the relationships between men and women, social and political role of women, among many others (Vinokurova, 2010). However, very little is known about the gender perspectives on vulnerabilities and adaptive capacities to climate change in Yakutia. Therefore, it is important to understand gendered perceptions of climate change and impacts on the indigenous livelihoods, gendered vulnerabilities to climate change and gendered adaptive strategies to climate change.

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Appendix I

Interview questions

Section1. Personal information

Q1. Name

Q2. Age

Q3. Sex

Q4. Education

Q5. Profession

Section 2. Subsistence harvesting

Q6. Tell me about what you do and how you make a living?

Q7. What plant and animal species do you harvest for your daily life? For trade?

Q8. What species do you harvest in tundra?

Q9. What species do you harvest in taiga?

Q10. Are there any changes in harvesting at both sites?

Q11. What species do you fish for your consuming? For trade?

Q12. Do you buy food at a shop or consume only harvested species?

Section 3. Perception of biodiversity

Q13. What is nature for your life?

Q14. Do you know a number of species increasing or decreasing? Do you experience problems with increase or decrease of species number?

Q15. Is it important for you to have different species in the environment? Why?

Q16. Why don't you harvest all species, e.g. grass, parasites?

Section 3. Environmental changes

Q17. What environmental changes have you observed over the last 10 years?

And then I will ask to show areas on a map where these changes have occurred

Q18. Have you ever observed changes in animal, plant and fish species over the last 10 years?

Q19. Is it good for you if there are changes in species (biodiversity)? Why?

Q20. Do you see any difficulties with transportation?

Q21. Have you ever heard about climate change? If yes, what will it bring to your life? What kind of changes do you expect?

Q22. Do you think what is the reason of climate change? Why?

Q23. How does climate change affect your life? Is it positive or negative?

Section 4. Adaptation to changes

Q24. What measures do you take to prevent environmental changes?

Q25. How do you adapt to climate change?

Section 5. Cultural ecosystem services

Q26. Is it now possible to use traditional knowledge (in weather prediction, hunting, fishing, herding etc)?

Q27. Have the recreational and cultural traditions changed? Why? (In terms of going to sacred places they used to go before, organizing cultural customs etc)

Curriculum Vitae

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EMPLOYMENTS_____

09/2013 - present	Department of Geography, University of Zurich PhD student in Human Geography Funded by a grant from the Swiss Government Excellence Scholarship and the University Priority Programme Global Change and Biodiversity (URPP GCB).
05/2012 - 08/2013	BEST Center, North-Eastern Federal University Managing Engineer
11/2009 - 08/2013	Institute for Biological Problems of Cryolithozone Secretary for International Projects
12/2006 - 08/2009	YARKO Consultant
09/2005 - 06/2006	Altan Secondary School English Teacher
09/2004 - 06/2005	Berezina Primary School English Teacher

EDUCATION_____

09/2013 - present	Department of Geography, University of Zurich PhD student in Human Geography > Dissertation in Human Geography: "No Fish, No Nimat": Arctic Social-Ecological Systems in the Context of Global Change (in English)
09/1999 - 06/2004	Faculty of Oriental Languages, Far-Eastern State University for Humanities Diploma in Philology > Thesis in Chinese Philology: "Popular Vocabulary of Chinese Youth" (In Russian)

FURTHER TRAINING_____

02/2016	Graduate School in Geography Scientific Writing in the Social Sciences
08/2015	FORS Swiss Summer School on Social Science Methods
03/2015	Graduate School in Geography Time and Self Management
09/2014	International Graduate School North-South Summer School on Governance, Economy,Sustainability
05/2014	Graduate School in Geography Voice Training and Presentation Skills

SCHOLARSHIPS_____

2017 Fellow of the Social and Human Working Group, International Arctic Science Committee (IASC)

2013-2016 Swiss Government Excellence Scholarship for Foreign Artists and Scholar(ESKAS)

TEACHING_____

HS 2017	External examiner
FS 2016	GEO199 Tutorials - Small Teaching Group
HS 2015	GEO199 Tutorials - Small Teaching Group
FS 2015	Excursion to Geneva

PUBLICATIONS_____

Stanislav Ksenofontov, Norman Backhaus, Gabriela Schaepman-Strub (2017): To fish or not to fish?: fishing communities of Arctic Yakutia in the face of environmental change and political transformations. *Polar Record*, 53 (3), 289-303. Editor's Pick

Susan A.Crate, Mathias Ulrich, Joachim Otto Habeck, Alexey R.Desyatkin, Roman V.Desyatkin, Alexander Fedorov, Tetsuya Hiyama, Yoshihiro Iijima, Stanislav Ksenofontov, Csaba Meszaros, Hiroki Takakura (2017): Permafrost livelihoods: A transdisciplinary review and analysis of thermokarst-based systems of indigenous land use. *Anthropocene*, 18, 89-104

Corine Wood-Donnelly, Bathsheba Demuth, Johanna Grabow, Bryan Lintott, Mia Landauer, Stanislav Ksenofontov, Dawn Berry "Awkward relationships with the melting cryosphere", *Polar Record, 2017 (in revision)*

Stanislav Ksenofontov, Norman Backhaus, Gabriela Schaepman-Strub "There are too many swans - but they are sacred": Indigenous knowledge of biodiversity change in Arctic Yakutia", *Polar Geography, 2017 (in revision)*

CORE PRESENTATIONS_____

"To fish or not to fish?": vulnerability of fishing communities of Arctic Siberia to environmental change and socio-political transformations", International Congress on Arctic Social Sciences, Umea, Sweden, June 2017.

"To fish or not to fish?": vulnerability of fishing communities to environmental change and socio-political transformations", American Association of Geographers meeting, Boston, USA, April 2017.

"Arctic under threat: biodiversity and the livelihoods of indigenous people of North-Eastern Siberia in a changing climate". IV International Conference "The role of permafrost ecosystems in a changing climate", Yakutsk, Russia, August 2014.

"Climate change and its impact on rural population of Central Yakutia". Workshop "Permafrost Dynamics and Indigenous Land Use", Arctic Science Summit Week, Helsinki, Finland, April 2014.